STUDIES ON THE CROWN CONCH *MELONGENA CORONA* GMELIN[1]

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ABSTRACT

Melongena corona was studied at several locations on the Florida Gulf coast. Salinity tolerances, as determined in the laboratory, correspond to salinities of habitats occupied by this snail. It can live for long periods down to 8‰, although ultimate survival requires higher salinities. *Melongena* can live in habitats subject to daily salinity changes ranging between 12 and 24 ‰. Higher salinities, approaching oceanic, are not harmful. Embryos and larvae *in capsulo* are more sensitive than adults to reduced salinities. The snail has been observed to feed on a variety of detrital and living material, including oysters, but the evidence makes it doubtful that the crown conch is a serious oyster predator. Reproduction of *Melongena* is typical of the prosobranch gastropods. The embryonic stages are described. Measurements of egg capsule size and content show a relation of these factors to the size of animals in the adult population.

INTRODUCTION

The crown conch, *Melongena corona* Gmelin, occurs in great numbers along the Florida Gulf coast, where its presence in shallow water habitats, particularly on intertidal oyster reefs, has drawn much attention to its feeding habits. The decline of oyster production in Tampa Bay has raised questions regarding the possible role of *Melongena* as a predator on *Crassostrea*. In addition, northwest of Tampa Bay to beyond Pensacola, the crown conch is often associated with poorly producing oyster reefs, and the casual observations of oystermen lead them to believe *Melongena* is the main reason for low oyster production. This paper reports aspects of the life history and ecology of this interesting gastropod both as a contribution to our knowledge of marine snails, and as an attempt to clarify the relationships between crown conchs and oysters.

A number of studies report aspects of *Melongena* biology that will not be discussed in this paper. Movements of crown conchs on and around oyster bars appear to be considerable, especially when animals are collected and released in a different place. Under these circumstances, Caldwell (1959) near Cedar Key, Florida, measured move-

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ments of at least 249 feet from the point of release. In addition, a low percentage of recovery of released animals during subsequent collecting trips indicates a dispersal of animals from the point of release. Numerous trawls in the area showed *Melongena* to be virtually absent in the subtidal zone. Hathaway (1958), in Alligator Harbor, Florida, found that animals removed up to 150 meters from the collecting station quickly moved back to the area where they were originally found. Untouched crown conchs remained within the small area of their preferred habitat for many months.

Both of these authors observed the absence of small *Melongena* on oyster bars, as well as the burying behavior of the animals, especially during cold weather. Hathaway (loc. cit.) found very small *Melongena* buried in the sand in the high intertidal zone among the roots of *Spartina alterniflora*. It was inferred that crown conchs move to oyster reefs after a period of growth in nursery areas. *Melongena* on oyster reefs were found to be sexually mature and predominantly female, whereas these animals on soft bottoms, beaches, and in salt marshes included immature animals, and had a sex ratio closer to unity.

The present study presents further observations of the ecology and behavior of *Melongena*. Experiments on salinity tolerance of adult *Melongena* were performed in St. Petersburg and in Tallahassee at the authors' respective laboratories. Field observations of hydrographic conditions under which these gastropods exist have supplemented the experiments. Other aspects covered in this paper are feeding habits, shell form and growth, reproductive activity and morphology, egg capsule deposition, egg capsule size and content, and external salinity variations tolerated by embryos within the egg capsules. The developmental stages of *Melongena* from the unfertilized ovum to the time of hatching are also described.

Most data concern *M. corona corona*, but some of the observations were made in the cline between *M. corona corona* and *M. corona johnstonei* (Clench and Turner, 1956).

Methods

Salinity tolerances were determined by placing snails in aquaria which were then maintained at given salinities. In the St. Petersburg experiments animals were kept in normal sea water, distilled water, and at intermediate salinities of 20, 15, 8, 7, 6, 5 and 0 parts per thousand, the last value being represented by fresh river water. In

Tallahassee similar experiments were carried out at 33, 21, 15, 13, 11, 10, 9, and 8 ‰. Salinities were measured with hydrometers. General activity and time of death, if it occurred, were observed.

Hydrographic conditions in areas occupied by *Melongena* were measured with most attention given to salinity. Areas studied in northwest Florida were the St. Marks River estuary in Wakulla County and Indian Lagoon in Gulf County. At St. Marks water samples were taken from the bottom as close to the oyster reef as the tide would

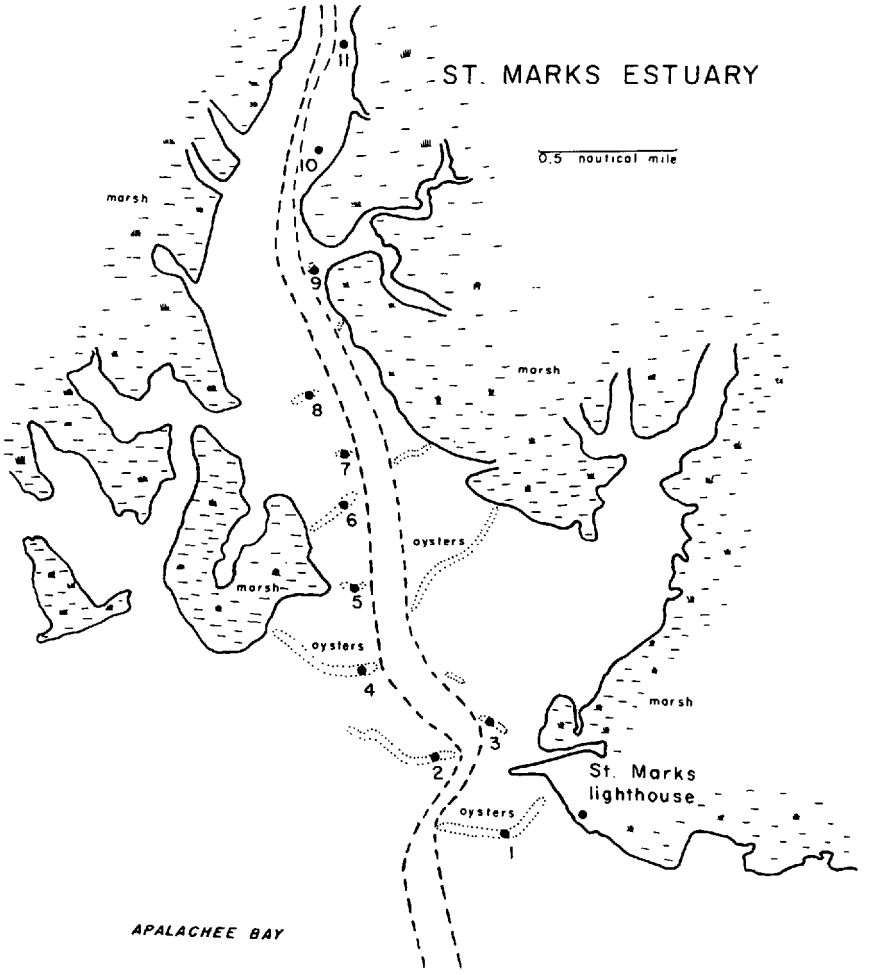

FIGURE 1. The St. Marks estuary, showing stations used in this study.

permit. The stations sampled at St. Marks are shown in Figure 1. Monthly samples from Indian Lagoon were taken from June, 1955 to May, 1956, and then only every three months until January, 1957. Downstate field observations were made in the Tampa Bay area.

The growth of individual animals was observed in specimens in which notches were filed in the growing edge of their shells. When collected some time later, even though the notches were filled in by later calcium carbonate deposits, their outlines were readily seen. and marked the starting point of growth from the day of filing. Growth of newly hatched *Melongena* was unsuccessfully studied in the laboratory. These efforts failed because the young tend to climb above the water level of the aquarium and die in that position (also see Turner, 1959).

Mating and egg capsule depositions were observed both in natural habitats and in sea tables.

Embryological studies were greatly facilitated by the abundance and ready availability of egg cases on Long Bar (Station 1) in the St. Marks estuary. It was possible to find newly laid strings of egg capsules and to rear them to hatching in aquaria. Under these circumstances developmental stages appeared normal as compared with embryos developing in the natural habitat. With laboratory reared embryos and larvae it was possible to follow the normal sequence of development and to estimate the duration of each stage. With knowledge of normal development it was possible to study deviations from normal caused by reduced salinities. A series of experiments was undertaken in which a string of egg capsules was split up into groups of two capsules each. Each group was placed in an aquarium and kept there at a given salinity. At the end of seven days one capsule of each pair was removed and the embryos were examined to determine the stage of development. At the end of another seven days the second capsule of each group was removed and examined. Salinities ranged from 8‰ to 32.8‰. Stages of development represented by embryos at the beginning of the experiment ranged from three days to ten days. Thus it was possible to see how more advanced embryos differed from those less advanced in their response to reduced salinities. Salinities were checked with hydrometers and adjusted with sea water and tap water.

Observations on developing embryos terminated development since the embryos die when removed from egg capsules. Observations were made with a binocular dissecting microscope with a calibrated ocular micrometer which enabled accurate measurements of the eggs and

embryos to be made. Sketches and photographs were used to record observations.

The number of capsules per string, length and width, and numbers of eggs, embryos, or larvae in each capsule were recorded.

Salinity Tolerance Experiments

In the St. Petersburg experiments the lowest salinity at which any adult snail survived for more than 11 days was 8‰. One snail survived for over 5 months at this salinity although it never showed any degree of activity such as climbing or moving around the bottom of the aquarium. When the experiments were terminated after more than 5 months, 80% of the snails initially in normal sea water and in salinities of 20 and 15‰ were alive and active.

In the Tallahassee experiments (Table 1) animals at salinities of 9.0‰ and below were inactive and died within 15 days, with the exception of one animal that died on the 19th day. Between 9.0‰ and 21.5‰ activities and survival of animals increased. Normal activity was seen at 12.8‰ and 15.0‰, but ultimate survival seems

TABLE 1

Activity and mortality of adult *M. corona* at reduced salinities. Entries indicate O: no activity, X: reduced activity, XX: normal or slightly reduced activity, D: death. Temperature 28°C. Two animals were kept at each salinity. Animals and salt water were transported from Alligator Harbor to the Florida State University campus where the experiments were carried out.

Salinity	Days of Continuous Exposure to the Reduced Salinity								
‰	4	6	8	9	13	15	19	27	29
8.0	O	O	O	O	D				
	O	O	O	O	O	O	D		
8.4	O	D							
	O	O	D						
9.0	O	O	O	D					
	O	O	O	O	O	D			
9.9	O	O	O	O	O	O	O	O	O
	O	O	O	O	O	O	O	O	O
11.0	O	O	O	O	D				
	O	O	O	O	O	D			
12.8	XX	XX	X	X	X	X	O	O	D
	XX	XX	X	X	X	X	X	X	X
15.2	O	O	O	O	X	O	O	D	
	O	O	XX	XX	X	X	X	O	O
21.5	XX	XX	XX	XX	X	X	X	XX	XX
32.8	XX	XX	O	XX	XX	XX	X	XX	XX
	XX	XX	XX	X	XX	XX	X	XX	XX

TABLE 2

EXPERIMENTS IN WHICH DEVELOPING EMBRYOS WERE EXPOSED TO REDUCED SALINITIES. A: ANOMALIES, D: DEAD, R: RETARDED, *N:* NORMAL, H: HATCHED. TEMPERATURE 28°C. ANIMALS AND SALT WATER WERE TRANSPORTED FROM ALLIGATOR HARBOR TO THE FLORIDA STATE UNIVERSITY CAMPUS WHERE THE EXPERIMENTS WERE CARRIED OUT.

Initial Day-Stage of Development	3		3-4		5		5		5-6		6		9		10	
Days Exposure to Lowered Salinity	7	14	7	14	7	14	7	14	7	14	7	14	7	14	7	14
Salinity‰																
8.0	A	D	A	D	A	D	A	D	A	D	A	D	A	D	R	D
8.4	A	D	.	. .	.	. .	.	. .	.	. .	A	D	.	. .	.	. .
9.0	A	D	.	. .	A	D	.	. .	.	. D	A	D	D	D	.	. .
9.9	.	. .	.	. .	A	D	A	D	.	. .	A	D	.	. A	R	D
11.0	A	D	.	. .	.	. .	.	. .	A	D	A	D	A	D	.	. .
12.8	.	. .	.	. .	A	D	A	A	A	A	.	. .	R	R	.	. .
15.2	.	. .	A	A	R	D	R	R	.	. .	.	. .	*N*	A	*N*	H*
21.5	A	A	R	. .	*N*	*N*	.	. .	*N*	. .	*N*	*N*	.	. .	*N*	H
32.8	.	. .	.	. .	.	. .	.	. .	.	. .	.	. .	.	. .	*N*	H

*These animals were ready to hatch but had died before doing so.

to depend on higher salinities. One *M. corona* was kept for five months without food at a salinity of 25.0‰ before it died.

At reduced salinities embryos are retarded in their development and often display anomalies (Table 2). Older embryos tolerate lowered salinities better than younger ones. When embryos as young as the third day stage of development were subjected to 21.5‰, anomalies occurred. Most older embryos developed normally at this salinity.

HYDROGRAPHIC STUDIES

The St. Marks Estuary. The St. Marks estuary consists of expanses of intertidal oyster reefs, sand beaches, sand and mud flats, and extensive salt marshes, as well as the main channel of the river (Figure 1). The reefs are made up of small coon oysters which occur in greatest abundance in the low intertidal zone. Higher up on the reefs the substrate is made up of broken oyster shells, packed and ground by the currents to form a hard substrate upon which few living oysters occur. The most notable hydrographic characteristics of the estuary are the effects of tides on conditions on the reefs and bottoms. At high tide the reefs are covered, but as the tide recedes an observer sitting in a boat soon

finds his horizons interrupted in every direction by large reefs. Long Bar (Station 1) is a good example. This reef extends about 900 yards into the mouth of the river, and at low tide it protrudes above water level 4 or 5 feet. The appearance of many such reefs turns the estuary into an alley of barriers with the channel running down the middle. On the reefs themselves the changing tides cause physical disturbances which must be considered in any biological appraisal of the area. The tranquility of full ebb changes to a complexity of eddies as the flood meets the flow of the river. The turbulence increases with the rising water and reaches a maximum when the opposing waters approach the reef tops. The patterns of currents over and around the reefs can be seen distinctly from a small boat. After the flood, the ebb joins the flow of the river to produce currents of high velocity. Interruption of this flow by the first exposure of reef tops increases the turbulence. The change of tide subjects the reefs to another factor—changing salinity. Salinity ranges in most parts of the estuary were found to be 10 to 12‰ (Figure 2). In addition to current and salinity, the biota must accommodate to seasonal changes in temperature which in the water

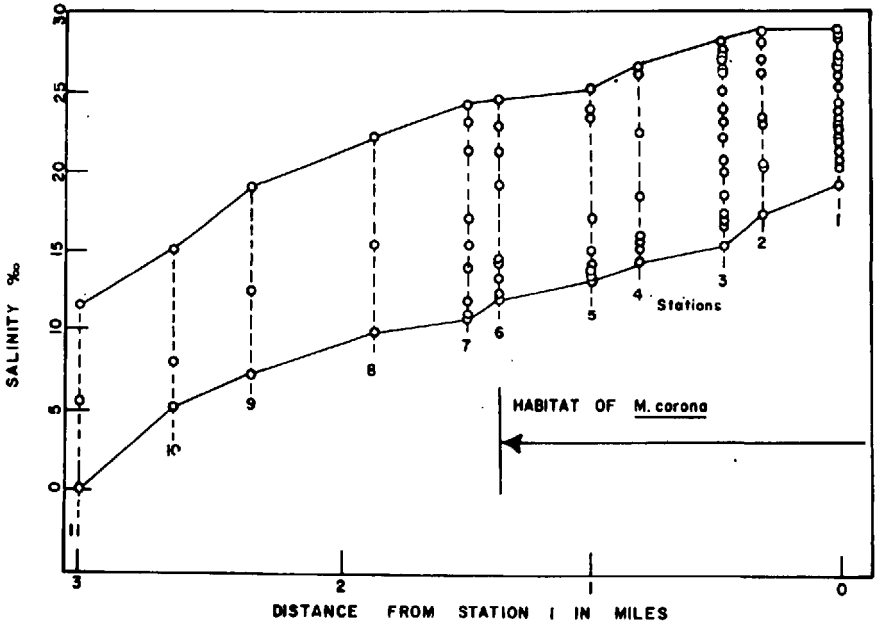

FIGURE 2. Salinities and distribution of *M. corona* on stations in St. Marks estuary.

can range from 10°C to 31°C and in the air from 0°C to over 35°C.

Studies at St. Marks have been carried out at certain stations on oyster reefs. Station 1 is on Long Bar. The other stations are up the river in the order of the numbers used to designate them. *Melongena* have been observed at Station 6 in moderate numbers and at all stations below it, but they are never seen farther up the river. *Melongena* are abundant on Long Bar, and on the intertidal grass flats in that part of the river.

TABLE 3

PHYSICAL DATA FROM THE REEF IN INDIAN LAGOON. THESE DATA TAKEN FROM MENZEL, HULINGS AND HATHAWAY (1958)

Date	Temperature °C	Salinity ‰
24 June 55	28.5	36.3
15 July 55	33.0	31.0
9 Aug. 55	32.0	29.1
15 Sep. 55	27.5	22.9
11 Oct. 55	23.0	29.5
15 Nov. 55	23.0	31.2
13 Dec. 55	8.0	29.1
24 Jan. 56	13.5	30.4
14 Feb. 56	15.0	23.5
22 Mar. 56	13.0	32.9
17 Apr. 56	19.0	35.3
22 May 56	27.0	36.6
11 Aug. 56	33.0	...
11 Sep. 56	25.0	23.9
18 Nov. 56	20.5	30.7
30 Jan. 57	26.5	26.5

Indian Lagoon. Indian Lagoon presents remarkably constant environmental conditions over a broad area. The Lagoon is 2 nautical miles long and is ½ mile wide at its broadest point. It is characterized by large tracts of intertidal oyster reefs. The subtidal bottom is very soft mud in all places except the mouth, where it is loose sand. Depth at low water is less than 6 inches. This shallowness results in very low vertical stability so that the slightest surface disturbance creates currents along the bottom and keeps the lagoon in a perpetually highly turbid condition. The intertidal shoreline supports a mixed mud-oyster-marsh grass community.

Observations were made in the middle of the lagoon where an oyster reef abounds with *Melongena*. This intertidal reef is about 200

by 20 yards in length and breadth. The bottoms adjacent to this reef are soft mud, the nearest solid bottom being more than ¼ mile away. Physical data for this reef are given in Table 3.

Feeding Habits

About 100 crown conchs were observed in Hillsborough Bay (Eastern Tampa Bay) feeding on fish scraps dumped from a bait house pier. In another part of Tampa Bay fifteen *Melongena* were discovered feeding on a dead horseshoe crab, *Limulus polyphemus*. Since the water was clear and there was a definite current where feeding was taking place an opportunity was provided for testing the relative sight and smell responses of *Melongena* under field conditions. The *Limulus* was freed of *Melongena* and placed 1½ yards down-current from them. Nothing happened after 15 minutes of waiting so the horseshoe crab was moved 1½ yards up-current from the conchs. Within fifteen minutes 12 of the 15 conchs had reached the crab and were rasping at its fleshy parts with their extended radulas. This suggests that *Melongena* is attracted to food by chemical stimuli in the water.

In Tampa Bay the crown conch is often seen feeding on banded tulip shells, *Fasciolaria hunteria*, which occur abundantly on oyster reefs.

To test whether *Melongena* kept in the laboratory were feeding on the lush growths of algae which occurred in the aquaria, an experiment was initiated in St. Petersburg with three aquaria at 32‰ salinity. Three snails were placed in an all glass aquarium of several gallons capacity and placed in the dark. Three snails were placed in each of two identical aquaria and exposed to light. After only a few days, only one snail remained alive in each of the three aquaria (one dark and two light). The dead ones were apparently victims of cannibalism.

This experiment ended when the last surviving snail in the darkened aquarium died after 872 days without feeding. Its light-exposed companion died after 114 days without feeding.

These findings indicate that *Melongena* can live for long periods without food.

An aquarium was maintained for six weeks in St. Petersburg during which time *Melongena* were fed both live oysters and shucked meats (*Crassostrea virginica*). The snails showed a preference for live oysters on which they were observed feeding. However, the actual initiation of feeding or attack was never observed. Live shrimp were

also placed in this aquarium, and when they died the snails consumed them.

The Florida horse conch, *Pleuroploca gigantea,* was the only species observed to prey on *Melongena* during this investigation.

Growth

The technique employed for measurement of growth did not give consistent information from which a representative growth rate could be computed. Caldwell (1959) reached a similar conclusion after using the same method. Evidently growth is irregular in the larger *Melongena* that occur on oyster reefs.

Reproduction

Most observations on mating and egg capsule deposition were made in the field at St. Marks and in Tampa Bay. Depositions were also observed in sea tables of the laboratory of the Oceanographic Institute at Alligator Harbor.

Mating.—One large group of *Melongena corona* was brought in from the field on July 1, 1956, and placed in the sea table. That night three pairs were observed to mate. The male holds the female firmly, his foot spread over the ventral side of her spire and covering the posterior of the aperture. In this manner, with siphonal canals in the same direction, the male is able to insert the penis. In the sea table this position was held from an hour and thirty minutes to an hour and forty minutes. The separation was rapid and complete. Copulating pairs will tolerate some little disturbance, since the three pairs in the sea table were transferred *in copulo* to another sea table, and copulation continued apparently normally. Seven pairs were seen mating on Long Bar during the daylight hours. No night field observations were made.

Egg Capsule Deposition.—Nine *M. corona* have been observed depositing egg capsules, eight at St. Marks and one in the sea table. The latter was one of the animals observed mating on July 1. After copulation, it had been insolated, and was discovered depositing capsules on July 19, a period of 19 days after mating. It deposited six capsules at that time. The time required to deposit these capsules was not determined, but prolonged periods of deposition are common in allied gastropods (Magalhaes, 1948; Ostergaard, 1950). One of the other animals mating on July 1 deposited 13 egg capsules some-

time between July 21-26, a period of 21-26 days since mating. This deposition was not observed.

In the field, deposition is never discovered until after it has been interrupted. The newly laid capsules are hidden by the female which is laying them, and they are, therefore, not seen until after the animal is picked up. The discovery of newly deposited egg capsules with no adult in the immediate vicinity is indicative that the female normally leaves the capsules as soon as they are deposited and shows none of the brooding behavior common to certain gastropods. (Ostergaard, 1950.)

Deposition is made on a solid substrate. At Long Bar strings have been found mostly on old shells and pieces of living grass. One string was found on the protruding neck of an occupied *Chaetopterus* tube. At the Alligator Harbor laboratory, egg capsules were found on the wooden sides of the sea tables, on the wire baskets in which the animals are kept, and on old shells left in the sea table. At Indian Lagoon one string was found on the shell of a living *M. corona,* and numerous strings were found attached to a very long piece of fencing wire resting on the soft mud bottom of the lagoon. In this instance suitable substrates were rare and many capsules had been deposited on capsules previously laid down. Deposition usually takes place on subtidal bottoms. Perry and Schwengel (1955) report intertidal deposition of *M. corona* egg capsules.

Male Genital Ducts.—The prominent penis is located to the right of the head. During normal activity it is carried concealed in the mantle cavity, folded flat against the visceral mass. The penis is somewhat flattened so that a cross-section of it is elliptical in outline. The end is forked, with one prong of the fork being larger and more rigid than the other. The smaller prong is folded against the larger one. The duct runs up the center of the penis to open at the end of the larger fork. From the base of the penis the duct proceeds along the visceral mass to the right, parallel to the lip of the mantle. It is seen in low relief in this position. At the far right side of the mantle cavity the duct makes a right angle turn to the posterior. Near the anus it is seen as a tube passing from the visceral mass into the tissue next to the rectum. At this point it is of larger diameter and represents the anterior part of the prostate gland. This rests on the right (inner) side of the animal, under the large kidney. The most posterior part of the prostate is just inside the pericardial cavity. The vas deferens enters the prostate gland at its midpoint. This tube connects the prostate with the

vesicula seminalis, a prominent coiled structure which passes to the gonad at the tip of the spire. The entire reproductive tract is a closed system, with all the ducts fused around their whole circumference.

Female Genital Ducts.—The most anterior duct is seen in relief on the right side of the visceral mass. It extends posteriorly from the orifice near the mantle edge to near the rectum, where it passes through the mantle cavity to the dorsal capsule gland. The capsule gland is an enlarged structure, quite obvious in the mature female, lying anterior to the large kidney and above the anus. Its posterior end is near the pericardial cavity. Back of the capsule gland is an assemblange of structures representing the albumen gland, the receptaculum seminalis, and the ingesting organ. Between the albumen gland and the ovary is the transparent and delicate oviduct.

Gonadal Activity.—Cytological examination of gonadal tissue from animals collected at St. Marks on February 14, 1957, revealed gametogenic activity in the testes but none in the ovaries. Gross examination of St. Marks animals on March 30, 1957, revealed gametogenic activity in both sexes; however, no egg capsules had been deposited on the reef up to that time. Experience during the summer of 1956 indicated copulatory activity in both sexes at St. Marks until at least the middle of July. In Tampa Bay copulation was first observed in February 1956, in water of 21°C, and was seen until mid-October.

Egg Capsules

The egg capsules are lens-shaped structures found in strings of six to twenty capsules each. These are illustrated in Clench and Turner (1956). Forty-nine strings from St. Marks have been examined and a mean value of 12 capsules per string calculated. The dimensions of

TABLE 4

Data on egg capsules from St. Marks and Indian Lagoon

	Mean	Range
Eggs per capsule (185 examined)	110 ±34	15 -273
Capsule length mm (192 examined)	13.6± 1.3	9.7- 23.0
Capsule width mm	14.2± 1.5	10.1- 23.0
Indian Lagoon		
Eggs per capsule (18 examined)	335 ±62	192 -560
Capsule length mm (121 examined)	20.1± 1.2	15.6- 25.8
Capsule width mm	21.2± 1.4	17.3- 25.8

the capsules have been measured (Table 4). The embryos within the capsules are suspended in a albumen-like material which becomes less viscous as the time for hatching approaches. A *Melongena* ovum has quantities of yolk which nourish the embryo, but it is possible that albuminous capsular material is consumed in later growth.

Extensive collection and examination of egg capsule strings indicate dimensions of the Indian Lagoon capsules are greater than those of the St. Marks capsules. Correspondingly Indian Lagoon capsules contain more eggs than do St. Marks capsules. Indian Lagoon *Melongena* are larger than those at St. Marks so these results are not surprising (Hathaway, 1958).

Development

The spherical ovum of *Melongena corona* measures 295-320 micra in diameter (Fig. 3a). The newly laid egg frequently has two polar bodies still attached to it. It consists largely of opaque yolky material with a little cytoplasm at the animal pole. Cleavage is preceded by a concentration of cytoplasm in the area where the spindle will form. The first cleavage furrow is accompanied by the formation of a small polar lobe. In two and four cell stages and for a short time after formation of micromeres the spherical shape is distorted into a two and four lobed figure. Shortly, however, the spherical shape is regained. The first two cleavages are holoblastic and equal. At this time it is possible to distinguish the poles by the concentration of cytoplasm (animal) and the appearance of the polar furrow (vegetal). The third and succeeding cleavages are concentrated around the animal pole and are unequal. These cleavages rapidly give rise to the first, second, and third quartets of micromeres. When the micromeres have divided enough to create a cap of ectoblast over the animal pole, the macromeres pull together to give the embryo a spherical shape once again (Fig. 3b). At this time the ectoblast begins the process of epiboly, the various stages of which have not been observed in detail in this study. It is only a matter of 24 to 48 hours from the ectoblastic cap stage to the time when embryos show ciliary movement and elaboration of the larval kidneys (Fig. 3c). These appear on each side, slightly below the equator, as large transparent hemispheres 40 to 50 micra in diameter. These structures are described in *Busycon* by Conklin (1897), and in *Fasciolaria* by Glaser (1905) as embryonic execretory organs. They persist for the whole of the embryonic life.

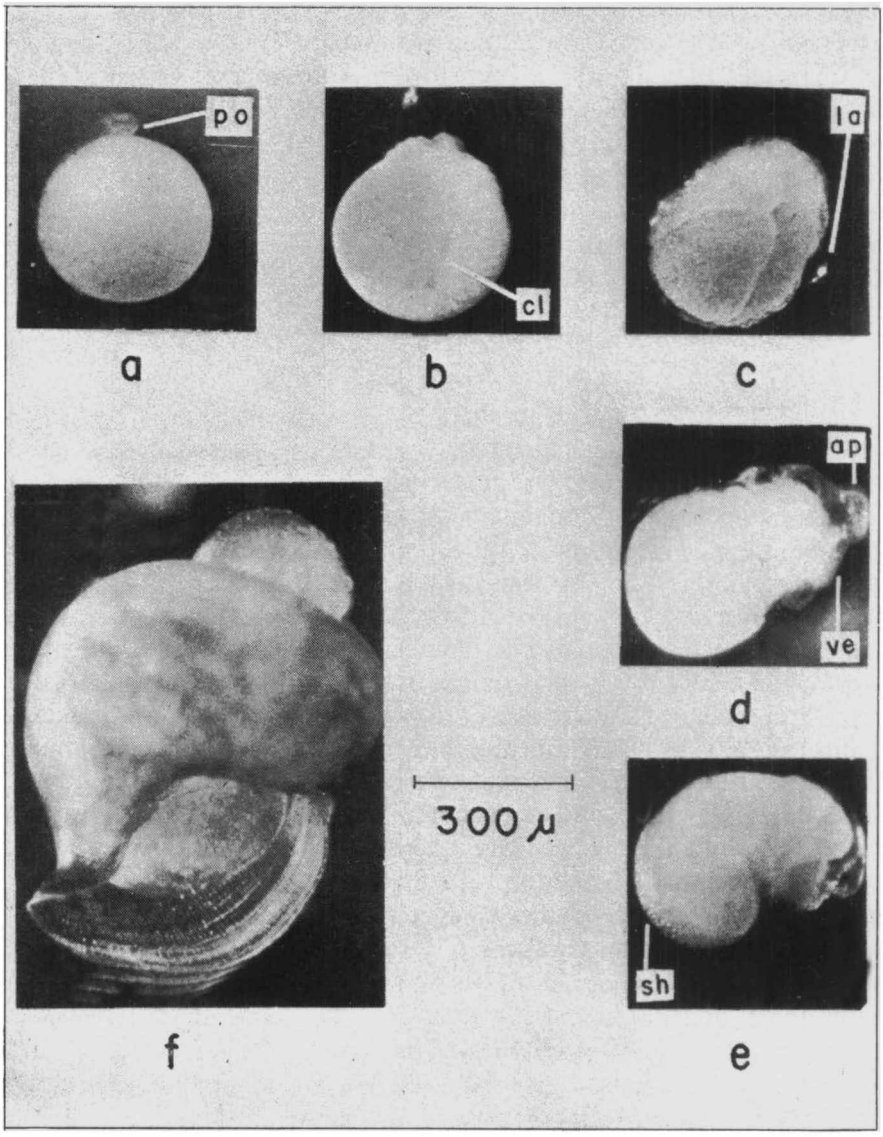

FIGURE 3. Development of *M. corona*. (a) uncleaved ovum, po: polar body. (b) ectoblastic cap stage, cl: cleavage furrow between macromeres. (c) trochophore, la: larval kidney. (d) early veliger, ap: apical plate, ve: velum. (e) early veliger, sh: shell cap. (f) shell at time of hatching.

Shortly before the appearance of larval kidneys the first movements of the embryo indicate the presence of cilia. A rudimentary velum soon appears, first as a bilobate protuberance just anterior to the vegetal pole and to either side of the ciliated apical plate (Fig. 3d), and then as large ciliated organs, with shapes suggesting butterfly wings (figures in Clench and Turner, 1956). At this time the large yolk laden cells of the fourth quartet are easily seen.

The first signs of shell deposition appear as the vellum begins to form (Fig. 3e). On the posterior surface of the elongating embryo a slightly granular cap appears. Its growth is continuous and rapid and is accompanied by organogenesis in other parts of the embryo. At the same time the volume of yolk material begins to diminish rapidly. The foot begins to develop shortly after the first appearance of the shell. Soon the stomadeum can be seen between the foot and the anterior part of the velum. Anterior to the mouth tentacles and eye spots appear. At the base of the velum and dorsal to it the larval heart is first detected by its rapid and regular contraction. The shell, as it grows over and covers the larval heart, first shows the asymmetry that results in a dextral animal. The siphonal canal appears at this time. By the time the animal is ready to hatch the shell has become an opaque structure with dimensions of 700 micra wide and 900 micra long (Fig. 3f). Clench and Turner (1956) state that the larva is not ordinarily pelagic.

An approximate timetable of development from the uncleaved ovum to hatching is given below. These embryos were reared at 28°C and at a salinity of 30.0‰.

Time Since Laying	*State of Development*
Up to 12 hours	Two cells
" 24 "	Four cells
" 48 "	Well defined macromeres and micromeres
" 72 "	Spherical shape restored. Ectoblast at the animal pole only.
Up to 4 days	Spherical. Diameter equal ca. 300 micra.
" 5 "	Slight elongation. First movement. Larval kidneys well defined.
" 6 "	Velum and shell gland rudiments obvious
" 7 "	Shell elaboration
" 8 "	First contractions of the larval heart
" 9 "	Heart almost covered by shell
" 14 "	Shell has 1¼ whorls
" 16 "	Shell has 1½ whorls
" 20 "	Hatching 700 x 900 micra.

Discussion

Salinity.—*Melongena* can tolerate not only low salinities, as shown in laboratory experiments, but also daily salinity variations of at least 12‰. At Station 6 in the St. Marks estuary a moderate number of crown conchs exist where salinities have been measured from about 12‰ to 24‰. Under these conditions, however, the animals do not carry on normal reproductive activity. On Long Bar, Station 1, large numbers of *Melongena* live and reproduce even though daily salinities have been observed to vary from 20-29‰ in a few hours. These observations correspond very well to the laboratory experiments, which show that adult *Melongena* tolerate much lower salinities than developing embryos. This implies that crown conchs further up the river have migrated from areas down the river where they were hatched.

Feeding habits.—The diet of the crown conch has often been discussed (Perry and Schwengel, 1955; Gunter and Menzel, 1957; Hathaway, 1958; Menzel and Nichy, 1958; Caldwell, 1959; Turner, 1959). The present report is in agreement with characterizations of *Melongena* as a scavenger. Olfaction appears to be the most important sense in this respect. With regard to the *Melongena* feeding on horseshoe crab, there is no way of telling whether the conchs had actually killed the crab or if they were merely continuing where disease or some predator had left off. Turbid or polluted waters, such as found near industrial regions of Tampa, do not deter crown conchs. They find food while gliding along on a muscular foot, with the siphon extended and waving laterally. Although the foot travels generally in a straight course, the body and shell are twisted from side to side through almost 180 degrees.

Evidence for serious predation of *Melongena* on commercial oysters is lacking in spite of efforts to prove that it occurs. In all cases in which the conchs have been seen feeding upon oysters, the conditions suggest that the oysters are in weakened conditions. This paper reports the consumption of oysters by *Melongena* in the laboratory (St. Petersburg) where the bivalves succumbed to predation under unnatural conditions. On oyster reefs, crown conchs appear to be most successful in inserting their probscises into oysters during the hot summer months. The internal temperature of an oyster was measured by Nichy (1956) in Alligator Harbor during August, and was found to be 37.6°C. Under these conditions Nichy found that he could open many oysters by compressing the valves anterior to the hinge ligament.

This is an indication of the weakened condition of these oysters. It probably indicates that most intertidal oysters in Florida are similarly weakened during the summers. Data of Menzel and Nichy (1958—Observations of 4 individuals of *Melongena* caged in their natural habitat, for a period of 165 days) and Hathaway (1958—Observations of 6 individuals of *Melongena* caged in natural habitats for up to 38 days, and of 6 in aquaria for 60 days) indicate that mortality due to *Melongena* predation is no greater than ordinary mortality. It is possible that crown conchs eat only sick and dying oysters. It is not uncommon to see *Melongena* on oyster reefs feeding on oysters. Menzel and Nichy (1958) observed this "rarely," and Caldwell (1959) reported it as "occasional."

Data from the present report regarding salinity tolerance and distribution of *Melongena* indicate that crown conchs cannot succeed in many of the areas where oysters flourish and grow to commercial sizes. Experience in Apalachicola Bay (Menzel, Hulings, and Hathaway, 1958) has shown that *Melongena* does not occur on subtidal oyster reefs which are regularly flushed by fresh or brackish river water (*e.g.*, Station 2. Menzel, Hulings, and Hathaway, 1958). On such reefs, not only crown conchs, but many proven oyster predators are absent. Probably, reduced salinities account for this.

In areas where crown conchs occur, subtidal oysters are rare. The restriction of oysters to the intertidal zone has been studied by Nichy (1956) who demonstrates very clearly that predators such as *Busycon contrarium* and *Murex pomum* are highly effective in killing oysters in Alligator Harbor. Since these proven predators occur mostly below mean low water, and since *Melongena* is mainly an intertidal animal, it seems likely that a lack of subtidal oysters is due to *Busycon, Murex,* and other predators.

The evidence indicates that in the comparatively highly saline waters in which *Melongena* occur, oyster mortality is probably due to some other factors. Environmental causes such as the high temperature on intertidal reefs, high salinities, and the activities of proven predators, probably account for low oyster production in places where crown conchs abound.

In the experience of one of us (KDW) who for the past several years has been involved in ecological studies encompassing most of the oyster producing area of Florida, the depredations of man clearly appear to be an additional significant factor in the decline of oyster productivity.

Shell Growth and Form.—On the basis of shell form, Clench and Turner (1956) have said that two subspecies of *M. corona* live on the north coast of Florida. The cline between subspecies *M. corona corona* and *M. corona johnstonei* is said to cover the area of the present study. Populations from Indian Lagoon and St. Marks are widely separated geographically and display differences between each other which can be appraised in terms of the cline. *M. corona* of Alligator Harbor and St. Marks bear a close resemblance to *M. corona corona* as described and pictured by Clench and Turner (1956). Since Alligator Harbor is within the range given for *M. corona johnstonei,* one might expect to find there a form more closely resembling the latter subspecies. The appearance of Alligator Harbor animals is different from that of animals from Indian Lagoon. The latter animals closely resemble pictures and description of *M. corona johnstonei* as given by Clench and Turner (1956). Indian Lagoon animals possess a corollary row of spines near the anterior of the shell, a trait present in *M. corona corona* but absent in the more western forms of *M. corona johnstonei.* With respect to spire length, coloration, corrosion of the spines, however, Indian Lagoon animals are typically *M. corona johnstonei.* It would thus appear that populations sampled in this study represent stages of the cline between the two subspecies. An Indian Lagoon animal, resembling *M. corona johnstonei,* and a St. Marks animal, resembling *M. corona corona,* are shown in Figure 4.

When one considers the process of growth in which later whorls

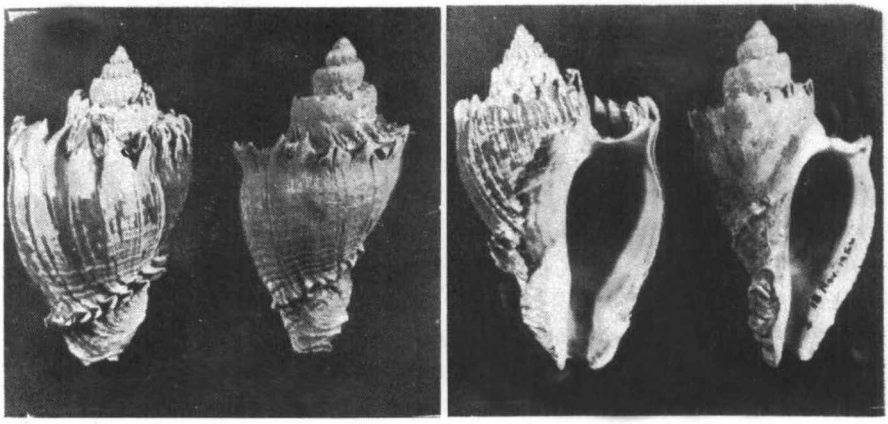

FIGURE 4. Left: *M. corona* from St. Marks, right: *M. corona* from Indian Lagoon.

wind around earlier ones, the question of the fate of the row of corallary spines must be considered. These spines, formed just posterior to the siphonal canal, are eventually located on the parietal wall of the aperture, in which position they present an obstacle to the movement of the animal in and out of its shell. Examinations of many shells have indicated that the animal has some way of removing these obstacles. By the time the new whorl has grown around, the corollary spines of the previous whorl have been removed, and the former outer surface of the shell has been smoothed over. There is no information on how these spines are removed. It is suggested that the mantle may have the ability to resorb or dissolve the calcium carbonate of the shell when any part of it becomes undesirable. Since the mantle is the structure adapted to deposition of the shell, it might also have a resorption function.

An anomaly within the main population at St. Marks was seen when a large (168 mm) animal was collected whose shell was perforated with boring sponges. Ordinarily *Melongena* are not infested with boring sponges. Two sponges were tentatively identified as *Cliona celata* Grant, and *C. caribboea* Carter. Determinations are based on the size of the megascleres and the absence of microscleres (Old, 1941). An attempt to relate this information to the "Cliona" zones (Hopkins, 1956) postulated for Gulf coast estuarine waters can lead only to the conclusion that the individual *Melongena* in question had not spent any time in waters more brackish than those in which it was found, since *C. celata* is one of the species found in the more saline waters, and *C. caribboea* is thought to have similar preferences.

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Conclusions

1. Large groups of *Melongena* thrive in areas of the Florida Gulf Coast where salinities show ranges from 20 to 29‰ with each change

in tide. Higher salinities are no barrier to this animal, and it is quite capable of living at lower salinities since moderate numbers have been found in places with a daily salinity range between 12 and 24‰.

2. Adults of *Melongena* tolerate lower external salinity than larvae *in capsulo*.

3. *M. corona* feeds on a wide variety of living and dead material. It is probably of considerable importance as a scavenger. A good sense of "smell" guides it to food in the highly turbid water where it often lives.

4. Observations on oyster reefs establish that *Melongena* sometimes feed upon intertidal oysters. In the St. Petersburg laboratory *Melongena* in aquaria consumed live oysters; however, as previously reported, captive crown conchs in northwest Florida did not contribute to oyster mortality. The lack of exhaustive experimental evidence leaves open the question of the degree to which *Melongena* predation is a factor in oyster mortality.

5. The intertidal distribution of *Melongena* and its well defined limited tolerance for fresh water eliminate it as a threat to subtidal oyster bottoms in estuaries regularly flushed by fresh water.

6. Growth appears to occur in spurts between periods of rest. This is common in marine gastropods (Abbott, 1955). No growth period, seasonal or otherwise, was found to be common to an entire sample population.

7. Reproductively, the crown conch is typical of the prosobranch gastropods. The genital tract is of an advanced, closed type. The course of larval development follows the general pattern of gastropod eggs with large amounts of yolk. The shell of the hatched larva is relatively massive, which may account for a brief or non-existent pelagic life.

8. Egg-capsule size and egg content are related to the size of the animal depositing them. In populations of large animals an average of 335 eggs per capsule were counted, whereas in a population of smaller animals this figure was 110.

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