A NOTE ON EGG DEPOSITION BY *DORYTEUTHIS PLEI* (BLAINVILLE, 1823) AND ITS COMPARISON WITH OTHER NORTH AMERICAN LOLIGINID SQUIDS[1]

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ABSTRACT

Observations on egg laying in *D. plei* are reported. The similarities and differences of the egg deposition process, the egg mass structure and the mode of attachment in other North American loliginid squids are compared with that of *D. plei*.

INTRODUCTION

In mid-March, 1965, a single specimen of the loliginid squid *Doryteuthis plei* (Blainville, 1823) was dip-netted at the dock of the Institute of Marine Science and placed for observation in a concrete tank of running sea water. The squid had a dorsal mantle length of 125 mm. It is a commonly-known and disappointing fact that squid generally do not survive in captivity for more than a few days, so that when the above-mentioned specimen remained in good condition without signs of deterioration, it was transferred to a large glass-walled aquarium tank for closer observation. The squid fed regularly on small fish of the genus *Cyprinodon*. One week after capture, the squid laid a mass of fertilized eggs. Four nights later, another egg clutch was deposited, and the specimen showed no physical or behavioral signs of poor condition. It is generally regarded that loliginid squid die after spawning and this is specifically recorded for *Loligo opalescens* from waters off California (McGowen, 1954) and for *Loligo pealei* and *Sepioteuthis sepioidea* of the Western Atlantic (Arnold, 1965).

There are several references to egg laying by loliginid squid in North America, the classic of which remains Drew's observations on the sexual activities of the squid *Loligo pealei* (1911). McGowen (1954) observed mating and egg laying by *L. opalescens* in Monterey Bay. More recently Arnold has reported on mating behavior in *L. pealei* (1962) and *Sepioteuthis sepioidea* (1965).

To date, nothing has appeared in the literature on any phase of the biology of *Doryteuthis plei*. This note describes the various aspects of egg deposition in *D. plei* and compares and contrasts this segment of reproductive biology with that reported for other species of North American loliginid squids.

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OBSERVATIONS

During the course of its captivity, the female *Doryteuthis plei* deposited egg masses on two different occasions. The first egg mass was laid on the seventh night after the squid had been captured. This was the first night that she had been placed in a large, glass-walled aquarium tank which had a capacity of about 75 gallons. Three sides were covered to give a background. The bottom of the tank was covered with a one-inch layer of coarse sand, but there were no rocks, shells or other hard objects present. There were no other objects in the tank, save the water inflow and outflow tubes. Egg deposition occurred in a completely darkened lab between the hours of midnight and 8:00 a.m. and consequently was not observed. No additional strands were affixed to the egg mass after this time.

The base of the egg mass was located beneath the surface of the sand, and it was originally thought that the entire mass had been attached to the bottom of the tank, because there were no hard objects available to which the female could attach her eggs. However, closer inspection revealed that the mass was not fixed to the bottom of the tank, but, rather, that the basal ends of the strands had been deposited in the sand layer. The entire foundation of the egg mass thus consisted of the congealed ends of the individual strands which encased the sand grains into which they were laid. Throughout the period of its existence the egg mass maintained the shape and unity of its base in the sand. The basal ends of the strands were not complexly interwoven as they are in *Loligo pealei* (Arnold, 1962), but they arose individually from the gelatinous base and radiated out and upward.

The first mass of eggs consisted of 63 individual strands which, when first observed, were quite long and thin. After about three hours they appeared to have shrunk and ranged in size from two to four inches in length, but soon these swelled to about eight inches in length. At least a

portion of this elongation was due to the appearance of minute bubbles on the capsules and occasionally in the ends of the strands. Each strand contained an average of about 180 eggs closely packed in a spiral fashion around the clear gelatinous axis of the strand (Fig. 1a). Fewer eggs were located toward the bases and the distal tips of the egg strings. The strands in the center of the mass were longer and contained more eggs than those around the periphery of the clutch.

A second clutch of eggs was laid in the tank four nights following the deposition of the original mass. The new mass was deposited in the sand about a foot and a half from the first clutch, and in appearance and attachment it closely resembled the original mass, although it was only about half the size. The entire mass was made up of 33 egg strings with an average of about 90 eggs in each strand. Again, the outer strands were smaller and contained fewer eggs.

The eggs from both masses were fertilized and developed quite rapidly so that the first squid embryos hatched as extremely small larvae ten days after they were laid. However, a considerably greater percentage of eggs in the peripheral strands of the second mass were unfertilized. This fact, plus the size discrepancy between inner and peripheral strands of both masses, is an indication that the female deposits the egg capsules beginning with a central core and gradually adding on around the outer edges. Arnold (1962) has reported that *Loligo pealei* deposits its strands into the center of existing masses. Since mating had occurred prior to the capture of the squid and both masses of eggs were fertilized, it is apparent that the sperm of *Doryteuthis plei* remain viable within the female for at least 11 days.

The observable physical condition of the female squid appeared excellent after the deposition of both egg masses. Other than a slight reduction in girth, no physical deterioration of the squid was noted. She continued to be active and normal in her swimming and feeding behavior. After spawning, the nidamental glands and accessory nidamental glands, which were clearly observable through the mantle, retained the creamy white coloration seen prior to egg laying. In *Loligo pealei* the accessory nidamental glands have a bright red or orange pigmentation (Drew, 1911; Costello *et al.*, 1957; Arnold, 1962).

For the first half-day after the original egg mass had been deposited the female appeared to stay in the vicinity of the clutch rather than swimming the full length of the tank. Generally she swam back and forth in the normal "rocking" manner over the mass of egg strands which were gently moved about by the water currents set up by the squid's funnel and fins in swimming. However, it cannot be concluded from this observation that this behavior was an attempt to bathe the clutch as is commonly the case with some octopods. Occasionally the female would descend close to the bottom and move in to investigate the egg mass (Fig. 2). She would insert her head

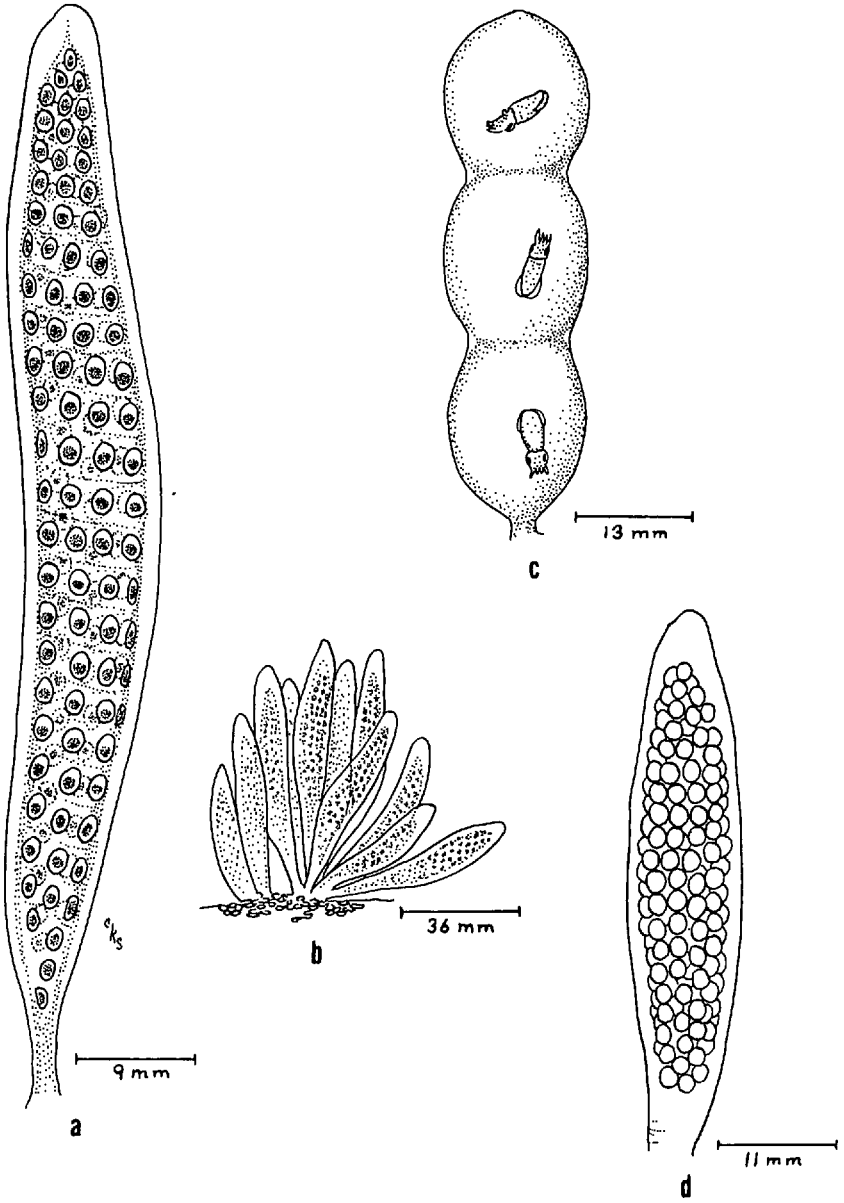

FIGURE 1. (a) *Doryteuthis plei* egg capsule. (b) *D. plei* egg mass. (c) *Sepioteuthis sepioidea* egg capsule in advanced stage. (d) *Loligo pealei* egg capsule (after Verrill).

FIGURE 2. *Doryteuthis plei* investigating the egg mass.

and arms into the middle of the mass, feel around with the arm tips, pump several spurts of water from her funnel, and then splay her arms out for a few seconds before resuming her normal swimming attitude. The investigation of the egg mass continued to occur every 10-15 minutes for several hours. This investigative behavior was not observed to persist in the days following the first day after laying, nor was it noticed after the deposition of the second clutch of eggs. However, it must be noted that the squid was not under constant observation, and, in particular, not just prior to the deposition of the second egg mass. Arnold (1962) noted that *L. pealei* investigates existing egg masses, and this serves as a stimulus to mate selection and egg laying.

Discussion

Arnold (1962) has discussed the nature of the visual stimulus which elicits the mating and egg laying responses in *Loligo pealei.* Mate selection and subsequent egg laying are induced in this species by the presence in the tank of a natural or an artificial egg mass. In the absence of this stimulus egg deposition may take place on "anything that resembled an egg mass." If deprived of a stimulus for a long period females would lay separate egg strings, but these were never brought together in the typical egg mass. The female of *Doryteuthis plei,* upon which the present observations are based, laid a large, well defined egg mass in complete darkness in the apparent absence of any stimulus which resembled an egg mass. The tank was barren save for the sand bottom and the water inlet and drain. Any visual stimulation would have had to take place prior to the lights being turned off, and it is not possible to say how soon afterwards the egg deposition commenced. The original egg mass, of course, could have provided the necessary visual stimulus for the deposition of the second mass four days later, although this new clutch was not attached to the original mass and it too was laid in the dark, perhaps under a delayed visual stimulus or a tactile stimulus from the original mass. In both *Loligo pealei* (Verrill, 1882; Drew, 1911; Arnold, 1962) and *L. opalescens* (McGowen, 1954) new egg capsules are deposited directly onto already existing masses. It may be that in the prolonged absence of a positive stimulus the specimen reported upon here undertook the original egg laying spontaneously. *Sepioteuthis sepioidea,* another loliginid squid, apparently does not respond to the stimulus of an egg mass for mate selection, but does lay eggs in the presence of existing egg masses (Arnold, 1965). However, the new egg masses are not attached in any way to the old masses. In this regard, egg deposition by *D. plei* resembles that of *S. sepioidea.*

Egg laying in *L. pealei* (Drew, 1911; Arnold, 1962), in *L. opalescens* (McGowen, 1954), and in *S. sepioidea* (Arnold, 1965) generally follows soon after copulation. Drew (1911) mentions the possibility of retention of the sperm in the female "for at least some weeks," but at that time he had

no indication of just how long. The female under present discussion had been in captivity for seven nights before she laid the first clutch of eggs. The second fertilized egg mass was deposited 11 nights after the squid was captured. Thus, sperm can remain viable in female *Doryteuthis plei* for at least a minimum of 11 days after mating. This assumes mating occurred just prior to capture, which may or may not have been the case. A post-mortem inspection revealed no sperm reservoirs attached within the mantle cavity or on the spermatophore pad of the buccal membrane. Thus, long term sperm retention probably does occur in the sperm receptacle as intimated by Drew (1911) and McGowen (1954).

For the attachment of egg masses *Loligo pealei* prefers hard objects such as seaweeds or other common support (Verrill, 1882), protruding stones, shells and water pipes (Drew, 1911), other submerged objects (Costello, *et al.,* 1957) or intertwined on other egg masses (Arnold, 1962). *Sepioteuthis sepioidea* commonly attaches its egg masses onto the under side of queen conch (*Strombus gigas*) shells (Arnold, 1965). Mr. W. Zeiler (personal communication) has collected *S. sepioidea* eggs which were attached to branching sea weed, possibly old *Sargassum,* and to the end of a sponge. While diving on a rubble reef, Mr. G. Hendrix collected a mass of *S. sepioidea* eggs attached to the underside of a small coral head (personal communication).

Females of *Loligo opalescens* attach their eggs into the sandy bottom or onto the base of a previously laid mass (McGowen, 1954). *Doryteuthis plei,* as reported here, likewise laid its egg masses in the sand but does not appear to attach them to existing egg masses. In the holding tank a solid substrate, the bottom of the tank, was available for attachment, but the eggs were clearly attached to the sand grains. The foundation or base of the egg mass appeared to be firmly enough attached in the sand to hold the mass in place. In nature the egg masses possibly are deposited on the sandy bottoms of bays where they would not be subjected to excessive wave or current action. If there were excessive wave action or currents, the egg mass probably would require a firmer foundation.

The number of egg strands laid by individual females of the loliginid species under consideration appears to be quite variable. Drew (1911) records the usual number for a continuous laying period in *L. pealei* to range between 1 and 6, but one specimen deposited 23 strings. *Sepioteuthis sepioidea* ranges between 11 and 39 strings per mass with an average of about 24 (Arnold, 1965). *Doryteuthis plei* seems to be fairly prolific in the number of egg strings produced—between 33 and 63. Figure 1 illustrates egg capsules of several species of loliginid squids.

In the literature there appears to be some confusion concerning the fate of the squid after spawning. *Loligo opalescens* clearly undergoes a mass mortality as evidenced by the direct observation of McGowen (1954).

However, Fields (1950) records that both sexes are in very poor condition after spawning but does not mention that they die. He does suggest that squid schools migrate to certain areas, viz. Monterey Bay, for spawning, then leave. A. E. Verrill (1882) believes that *L. pealei* spawns while in its second year and may live up to four years. Possibly, the small proportion of 3- and 4-year-olds had never spawned. It may be significant that a largc majority of Verrill's older specimens were males. Arnold (1965) states that females of *L. pealei* die after spawning as do those of *Sepioteuthis sepioidea.* I can find no further mention in Drew (1911) or Arnold (1962) of the death of *L. pealei* after spawning. Dragovich and Kelly (1963) report that the sex ratio of mature *Lolliguncula brevis* is seven males per female. This may be an indirect indication of the death of the female, but survival of the male, in this species after spawning. The female of *Doryteuthis plei* not only did not die after laying a 63-string egg mass, she survived to lay a 33-string mass four nights later, after which she lived in an apparently healthy condition for nearly a week.

It is interesting to note that there appears to be no information available concerning egg deposition and egg masses of *Lolliguncula brevis,* a very common inshore squid which ranges from the Middle Atlantic States, through the Gulf of Mexico and the Caribbean, and along the South American coast to Rio de la Plata (Voss, 1956). Dragovich and Kelly (1963), although they reported on a large number of fully mature *L. brevis,* did not mention collecting egg masses during their survey in Tampa Bay. Dragovich (personal communication) informed me that neither he nor his associates have found *L. brevis* egg masses. Mr. Durbin Tabb (personal communication), who has been conducting an extensive ecological survey of the inshore waters between the upper Florida Keys and the Chatham River sincc 1957, likewise has never found egg capsules or masses of *L. brevis,* although immature and adult specimens are common throughout the area (see Tabb and Manning, 1961). Thus, for the present, the naturc of egg deposition in *L. brevis* remains an intriguing, unanswered question.

The above discussion, in which the various phases and conditions in the egg laying process of *Doryteuthis plei* are compared with those in other North American loliginid squids, indicates there is a certain amount of confusion and contradiction concerning this one small part of these squids' biology. It also indicates the danger of assuming for all species in a family that which has been found to occur in one species. Clearly there is a need for more detailed and extensive studies on the biology of this important cephalopod group.

Summary

1. *Doryteuthis plei* laid two separate egg masses in sandy substrate in an aquarium.
2. The female did not die immediately after spawning.

3. The eggs were fertilized by sperm which had remained viable for a minimum of 11 days.
4. The squid exhibited investigative behavior toward the original egg mass.
5. Egg laying in *D. plei* is compared with that in other loliginid squids.

SUMARIO

UNA NOTA SOBRE LA PUESTA DE HUEVOS POR *Doryteuthis plei* (BLAINVILLE, 1823), Y SU COMPARACIÓN CON OTROS CALAMARES LOLIGÍNIDOS DE NORTE AMÉRICA

1. *Doryteuthis plei* puso dos masas de huevos separadas en substrato arenoso en un acuario.
2. La hembra no murió immediatamente después del desove.
3. Los huevos fueron fertilizados por esperma que había permanecido viable por un mínimo de 11 días.
4. El calamar mostró comportamiento investigativo hacia la masa de huevos original.
5. La puesta de huevos en *D. plei* se compara con la de otros calamares loligínidos.

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