Spawning Period and Size at Sexual Maturity of Spider Conch, *Lambislambis* (L. 1758) (Gastropoda: Strombidae), in Selected Reef Areas of the Visayas, Central Philippines

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A study on spawning and size at sexual maturity of the economically important spider conch, ***Lambis lambis*** was done in the Visayas, Central Philippines (10°59'10.73"N 125°39'58.61"E) which is useful information for the sustainable management of the overexploited spider conch. Spawning period was determined using histological analysis of gonads and data on gonadosomatic indices, as well as observations of spawning in captivity. Size at sexual maturity was determined based on a scatterplot of gonadosomatic indices (GSI) against shell length and noting other characteristics such as the thickening of the shell and marginal digitations and development of the penis (male) or egg groove (female). Minimum legal size was conservatively estimated at 80 mm but an important consideration should be that the folds of the marginal digitations are thick and solid and the penis or egg groove are fully developed. Spawning takes place year round usually 1-5 days around new moon and full moon with peak seasons during February-May and September-October. As a management measure, closed season for collection of the species can be enforced during the peak spawning season to allow sexually mature individuals to reproduce prior to harvest.

KEYWORDS: *Lambislambis*, spawning period, size at sexual maturity, spawning in captivity

INTRODUCTION

The spider conch is common in the reef and intertidal areas of the Indo Pacific region including the Philippines, Solomon Islands, Indonesia, Malaysia, India and Japan (Hamel & Mercier, 2006; Poutiers, 1998) where it is harvested for food and the shell craft industry. The spider conch fisheries in some of these areas are either showing signs of overexploitation or are already overexploited. In India, Jagadis et al. (2012) indicates that six of the eleven species of the genus *Lambis* are categorized under schedule IV of the Indian Wildlife Protection Act of 1972, which means commercial exploitation is being banned. In Singapore, it is categorized in the Singapore Red Data Book as vulnerable (Davison et al., 2008).

In the Philippines, the spider conch, *Lambis lambis* (Linnaeus1758) is an economically important invertebrate. It is widely collected as food throughout the country (Poutiers, 1998; Germano et al., 2003; Hermosilla & Narido, 2007). It is sold in the market as boiled meat without the shell (150-250 Php/kg) or as fresh or live shell (3-10 Php/pc). The empty shell is also sold in the shell craft industry and even the operculum is sold at 2500-3000 Php/kg (Mazo et al., 2007). All parts of the spider conch are considered a source of income by fisherfolk. In some parts of the Visayas, the shell is collected almost daily from the wild except during bad weather conditions. A study on the spider conch fishery in Guiuan, Eastern Samar in the Visayas indicated that it is already overexploited based on the length frequency data analysis using the FAO ICLARM Stock Assessment Tool (FISAT II) (Mazo et al., 2007). This could be due to the unregulated and indiscriminate collection of the shell in the wild. Further studies that could be useful for the sustainable management of the spider conch are therefore much needed.

Determining the size at sexual maturity of the organism can provide information which could be used as basis for recommending a minimum legal size for collection. Furthermore, information on the spawning season can be used in aquaculture efforts as well as a basis for regulated collection or the establishment of open and closed seasons as possible means to be explored for sustainable management of *Lambis lambis*. Reproductive studies are important to support management efforts of any fishery resource (Stoner, 2012).

Many gastropods have already been studied to address problems of rapidly depleting stocks. For example, extensive

studies on the queen conch, *Strombus gigas*, have been reported, covering aspects of its reproductive biology (Appeldoorn, 1993; Appeldoorn, 1998; Aldana & Frenkiel, 2007; Frenkiel et al., 2009), fishery and population dynamics (Gascoigne & Lipcius, 2004; Stoner & Ray-Culp, 2000; CFMC [Conch Fisheries Management Council]/CFRAMP, 1999; Ehrhardt & Valle-Esquibel, 2008) and aquaculture (Shawl & Davis, 2004; Davis, 2005). This has led to various interventions to restore stocks including quota systems, collection moratoriums, gear restrictions, closed seasons, no-take zones and legal minimum size for collection (CITES, 2003). Export trade of the said species has been suspended by CITES (Theile, 2001; Acosta, 2006). Culture farms are also being established for aquaculture and reseeding wild populations. For *Lambis lambis*, a study was initiated at the Visayas State University to address the paucity of information for sustainable management. No data on reproductive biology of spider conch is yet available in the Philippines or elsewhere. This paper presents results on spawning period and size at sexual maturity of the spider conch, *Lambis lambis*, including spawning observations in the laboratory.

MATERIALS AND METHODS

In the reefs of Manicani Island, Guiuan, Eastern Samar (10º59'10.73" N 125º39'58.61"E), *Lambis lambis* are found in areas where there is an abundance of red and brown algae which serve as their food abound. The same is true in the Olanggo (10º16'35.32"N 124º04'33.37"E) and Caubian (10º12'49"N 124º6'2"E) Islands of Cebu. They are usually found at depths ranging from 1.5-5 m but they can also be found in deeper areas where fishing pressure is less. To determine gonadal development and size at sexual maturity, spider conches were collected from Manicani Reef, while samples used for the spawning in captivity were taken from the islands of Cebu.

Spawning period

Gonad staging

Approximately 30 individuals were obtained monthly to represent data for a period of one year for gonad histological analysis. Field sampling was done in January to June 2002 and July to Dec 2005.

Samples were measured for shell length (+0.01 mm) using calipers, and weight (g) using a Kern digital balance (+0.1 g). The gonad was removed by carefully breaking the shell to make sure that the gonad was intact. The samples were then preserved in Bouin's fixative for histological analysis. Gonad samples were processed into slides at the Microtechnique Laboratory of the University of the Philippines—Institute of Marine Fisheries and Oceanology. Developmental stages of gonads in prepared slides were determined from the predominant stage (i.e. ≥50%) of the entire gonad section based on descriptions of the different stages of development by Kennedy (1977) and Aranda et al. (2003). Gonads were classified into the following stages: Stage 1—resting; Stage 2—developing; Stage 3—ripe; Stage 4—spawning; Stage 5—redeveloping; and Stage 6—spent.

Gonadosomatic index

Gonadosomatic index was computed as GSI (%) = gonad weight (soft body weight—gonad weight) × 100. This was used to infer the reproductive cycle of the spider conch. Since it was difficult to determine the sex based on gonad coloration and sexes were difficult to separate in younger specimens, male and female GSIs were not segregated. GSI was computed for a total of 300 individuals.

Size at sexual maturity

The size at the onset of sexual maturity was determined using the gonadosomatic indices as described earlier. A scatterplot of the GSIs against shell lengths (mm) was made to determine the minimum length at onset of active gonadal development which could be a good indicator of size at sexual maturity. Shell length was measured from the siphonal canal to the tip of the spire. Observations on the appearance of sex organs (penis and egg groove) as well as the thickening of the shell were also noted as indicators of sexual maturity.

Spawning in captivity

From October 2011 to December 2012, mature male and female spider conches were collected by commissioned collectors from the reef areas of Cebu either during full moon or new moon. This was done to observe possible copulation or spawning of spider conches under laboratory condition. As much as possible, large individuals were

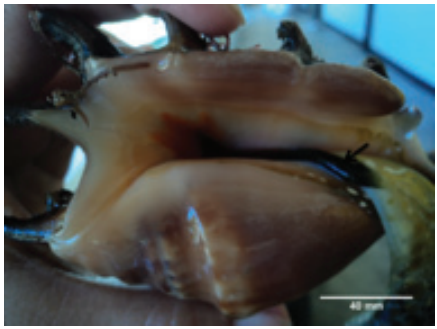

Figure 1. Sexually mature male *Lambis lambis* showing well developed dark penis (black arrow), thick shell lip and solid/closed marginal digitations (white arrow).

Figure 2. Sexually mature female *Lambis lambis* showing well developed egg groove (black arrow), thick shell lip and marginal digitations (white arrow).

collected to make sure that they are already sexually mature. Females and males were distinguished based on the presence of penis/verge in males (Figure 1) and egg groove in females (Figure 2). This was determined by holding the snails with the aperture facing the observer allowing the organism to extend its foot out revealing the verge or egg groove. If it did not extend out its foot immediately, it was stimulated by producing a sound through whistling (a technique used by locals to coax hermit crabs, which was also found to be effective for spider conches). Although not always reliable, sexes can also be determined using size as males are generally smaller than females. Using the external shell features, such as the marginal digitation, to differentiate the sexes was found difficult.

The spider conches were stocked in a conditioning tank in the laboratory with seawater and continuous aeration and fed ad libitum with a variety of brown, green and red algae such as *Sargassum sp., Ulva reticulata, Chaetomorpha crassa, Eucheuma* sp., and *Gracilaria* sp. They were stocked for possible copulation and spawning at a female to male ratio of 2:1.

RESULTS

Spawning period

The monthly gonad development stages of spider conch in Manicani Reef, Central Philippines are shown in Figure 2. Ripe and developing

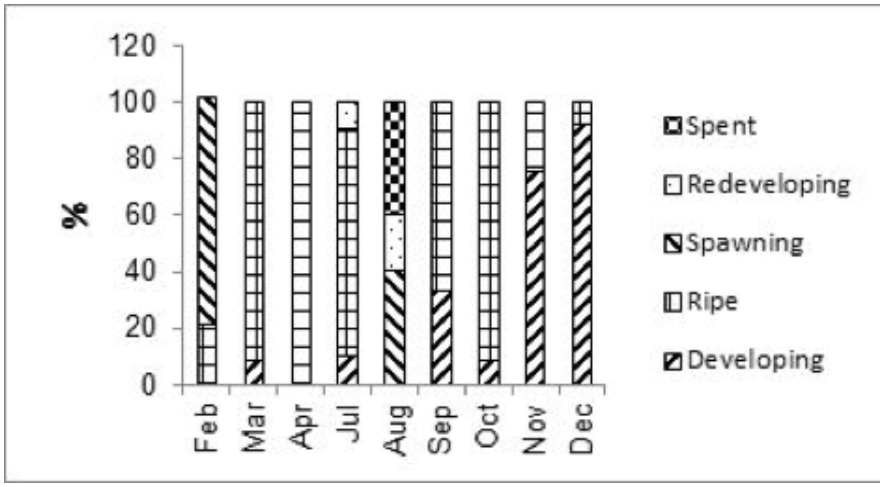

Figure 3. Percentage (%) of Lambis lambis observed in different stages from February to April 2002 and July to December 2005.

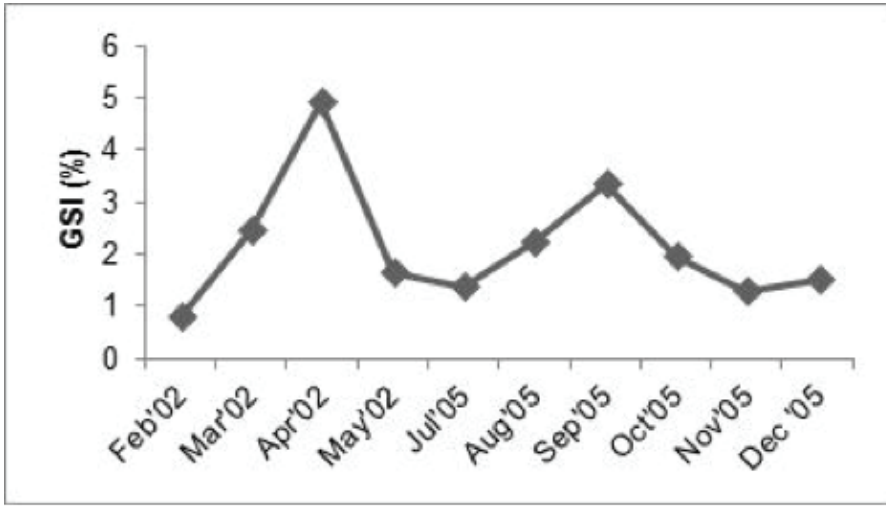

Figure 4. Gonadosomatic indices (GSI) of Lambis lambis from February to May 2002 and July to December 2005.

stages were observed in almost all months, with the highest numbers of individuals in ripe stage being observed during March, April, July and October. In agreement with this, peaks in GSI were noted during the months of April and September (Figure 3). Spawning stages were observed during the months of February and August, during which low GSIs were also observed.

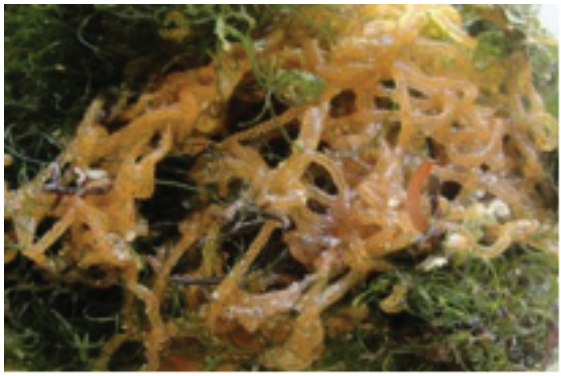

Figure 5. Laid egg mass of *Lambis lambis* with brownish to bright yellowish colored embryos inside a transparent tube.

Size at sexual maturity

Analysis of pooled monthly scatterplots of gonadosomatic indices (GSI) against shell lengths indicates active gonadal development at around 65-75mm shell length (Figure 5). In addition to this finding was the observation in the laboratory that immature individuals had thin shells and marginal digitations that are not yet fully formed as indicated by their open/non-solid folds, and underdeveloped sex organs - penis/verge and egg groove. Immature males have small, light colored penises (Figure 6A) while immature females have less distinct egg grooves (Figure 6B). Conversely, mature males had well developed elongated and darkened penises (Figure 1A) and females have distinct egg grooves (Figure 1B).

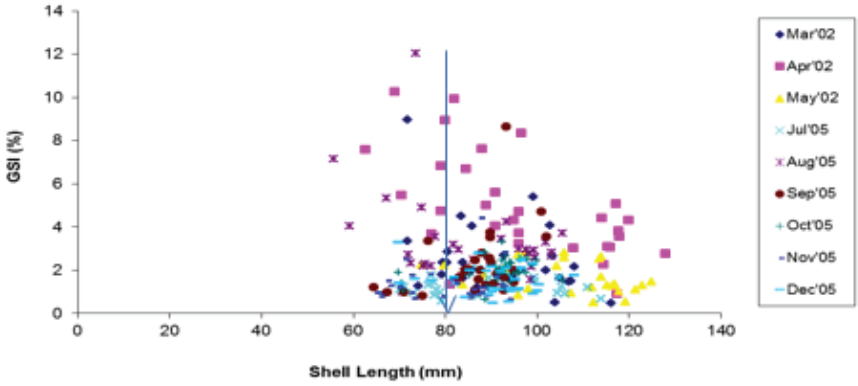

Figure 6. Scatter plot of gonadosomatic indices (GSI) against shell lengths (mm) of *Lambis lambis*. n = 300 individuals. Arrow is conservative estimate of length at massive sexual maturity.

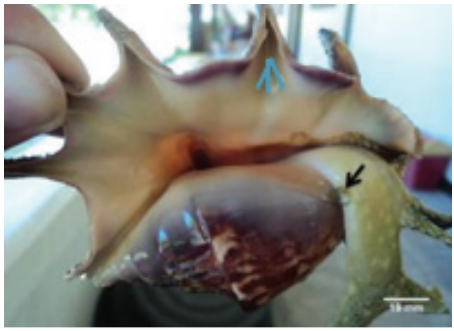

Figure 7. Immature male *Lambis lambis* showing underdeveloped penis (black arrow), thinner shell and open digitations (blue arrow).

Figure 8. Immature female *Lambis lambis* showing egg groove (black arrow) and thin undeveloped marginal digitations (blue arrow).

Mature individuals of both sexes also had thicker shell sand solid marginal digitations with closed folds. It was also noted that immature individuals having thin shells and underdeveloped sex organs could attain bigger shell lengths that could even reach up to >100 mm.

Spawning observations in captivity

Actual copulation and egg laying by *Lambis lambis* was observed for the first time in the Philippines under laboratory conditions in the months of October to December 2011, March to May 2012 and August to December 2012. Actual copulation in the laboratory was witnessed only once where the male and female spider conches faced each other with their marginal digitations somewhat interlocking. Throughout the observation period, there were egg layings that were observed one to five days before or after full moon. There were also instances that egg laying happened during or one to five days before or after new moon. The laid egg masses varied in size and consisted of transparent capsules with brownish to bright yellowish embryos inside (Figure 4).

Most of the laid eggs were found in the early morning, indicating that spawning had occurred during night time. However, actual day time spawning or laying of the egg mass was also observed in the laboratory on May 9, 2012. When laying the egg mass, the female extended out its foot and proboscis while positioned on its side with the marginal digitations facing up. A continuous strand of gelatinous filament that contained the eggs was laid through

the egg groove that runs through the foot. The female attached the egg filament to algal strands and available substrate in a maze of continuous coil with no specific pattern forming an egg mass. One of the medium sized egg masses was carefully uncoiled for length measurement and was found to be approximately 10 meters. The laying of an egg mass with this length was completed in ~7 hours. After laying, the female stayed near the egg mass, almost motionless. Some females were also found covering their newly laid egg mass with their shell.

DISCUSSION

Spawning period and spawning observations

Histological analysis of the spider conch gonad revealed that almost all months have gonads with developing and ripe stages, which indicates that spawning could be year round. However, the peak spawning season could be during February-May and September-October as indicated by the high number of ripe individuals during these months. This was corroborated by the GSIs which peaked during April and September indicating gonadal activity. These results on gonadal analysis were further corroborated by spawning observations in captivity. Year round reproduction was also suggested by Cardinas et al., (2005) on the reproductive pattern of *Strombus pugilis* in Mexico. Jagadis et al. (2012) indicated that spawning of *Lambis lambis* in India is seasonal, occurring during the months of October-December. In the study of Shawl and Davis (2004), egg mass production of *Strombus gigas* in captivity was continuous during warmer months while it slowed down or stopped when the temperature decreased during winter.

Based on our spawning observations in captivity, the female did not leave the spawn after laying the egg mass. Hamel and Mercier (2006) also observed such brooding or guarding behavior in *L. lambis* when they observed the organism, also in captivity. In contrast, Jagadis et al. (2012) who also observed *L. lambis* in captivity in India, found that the female left the egg mass shortly after spawning. Moreover, we found that an ~10 m egg mass was laid by *L. lambis* in ~7 hours, whereas egg laying took a longer time and was usually completed within 24 to 36 hours in *Strombus gigas* (Davis, 2005). The laid egg mass of *L. lambis* did not assume a specific shape unlike in other strombid species where the egg mass assumes a crescent shape (e.g. in *S. gigas*; Davis, 2005 and *S. canarum*; Cob et al., 2009).

We also found egg laying to occur during both day and night time although the spider conches were more active during night time and sought refuge in seaweeds during the day. Conversely, Jagadis et al. (2012) reported that spawning of spider conch occurs only during night time.

Size at sexual maturity

Although the onset of active gonadal development was at 65-75 mm, a more conservative estimate of length at maturity would be ~80 mm which could be used as the minimum legal size for both sexes. This is to allow the conch to reproduce prior to harvest. However, it is very important to emphasize that shell length should not be the only basis in determining sexual maturity but also the shell features and development of sex organs. Thus, the minimum legal size of spider conch that should be allowed for collection is 80 mm provided that the shell already thickened, the marginal digitations are closed and thick/solid, and the penis (male) or egg groove (female) is already well developed. In *Strombus* spp., internal reproductive structures and external genitalia develop simultaneously (Reed, 1995). In the queen conch, *S. gigas*, thickening of the shell is also used as the basis in determining sexual maturity. Theile (2001) indicated that queen conch do not start sexual maturity until the lip is 4 mm thick. Accordingly, 50% maturation is reached by the queen conch once the lip is 7 mm thick. However, Stoner et al. (2012) recently reported that the minimum lip thickness for sexual maturity is 12 mm for females and 9 mm for males. Although no actual measurement of lip or digital margin thickness was made in the present study, well developed sex organs (e.g. dark and elongated penis), in addition to thickened, solid marginal digitations are important indicators of sexual maturity. These characteristics are easier for the fisherfolk to determine. The observation on immature *L. lambis* individuals having shell length >100 mm indicate that the species grows by increasing shell length first, then later stops increasing in shell length and invests on shell thickening until sexual maturity is reached. Theile (2001) reported similar findings in *S. gigas*, which shows determinate shell growth. The shell stops increasing in length once the animal starts producing its typical large flared shell lip, and growth occurs by thickening of the shell especially the flared lip. Individuals that have started flaring their lips but have not yet reached sexual maturity are considered sub-adults. Theile (2001) further added that the linear growth of the shell and the flaring of the lip may occur simultaneously for some

time before the adult shell length is reached and the growth in shell length ceases.

In determining the minimum legal size for *Lambis lambis*, it is therefore important to consider not only the size but more importantly the thickness of the shell/marginal digitations and additionally, the appearance of the sex organs. It would then be useful to determine the specific thickness of the shell lip and marginal digitations of a sexually mature *L. lambis*. Furthermore, it is also worthwhile to determine the maximum shell length at which *L. lambis* starts to increase in shell thickness and stops increasing in length. However, for management purposes, especially at the fisherfolk level, using the structure of the marginal digitations in addition to the appearance of sex organs as indicators of sexual maturity would be easier to implement.

ACKNOWLEDGMENTS

We thank the Department of Agriculture—Bureau of Agricultural Research for the funds provided for the research on size at sexual maturity and gonadal development and the Department of Science and Technology for the funds provided for the research on spawning in captivity. We also thank Ms. Jennelyn F. Melgo and Ms. Julissah C. Evangelio for their invaluable help in data collection and processing; the Bureau of Fisheries and Aquatic Resources—Guiuan Station personnel for help with field data collection; the University of San Carlos-Marine Biology section and the Visayas State University Marine Laboratory personnel for logistic support.

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