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Gonadal Maturity of Sea Cucumber (Actinophyga echinites) as Basis for Fishery Resource Management

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Abstract

Sea cucumbers are necessary due to their important role in the sustainability and conservation of the fishery resource in the province, the future for aquaculture, and its economic aspect. Its objective focused on the gonadal maturity of sea cucumber (Actinophyga echinites) found in Ilocos Sur. There are 234 males and 180 females identified and categorized according to their maturity stages as immature, maturing, ripe, and spent stages. From the monthly determination of these maturity stages of both sexes, the ripe stage and GSI development were observed synchronous with male and female individuals. Size at first sexual maturity for males was 9.17 cm and females were 10.28 cm respectively. Size restriction and closure during the peak breeding season are determinants in maintaining and sustaining sea cucumbers. Further, catch size and minimum size limits will be introduced and enforced in areas with a high abundance of commercial species.

Keywords: Ganado-somatic index; size determination; maturity stages.

1. Introduction

Various threats have been identified for sea cucumber populations worldwide, including global warming, habitat destruction, and unsustainable fishing. The critical status of sea cucumber fisheries worldwide is compounded by different factors which include the lack of financial and technical capacity to gather basic scientific information to support management plans, weak surveillance and enforcement capacity, lack of political will, and socio-economic pressure exerted by the communities that rely on this fishery as an important source of income. The fast pace of development of sea cucumber fisheries and many sea cucumber species is at risk. As pressure on the environment from marine activities increases, marine living resources and their habitats are being lost or damaged byways that show diminishing biodiversity. This trend is the same in the sea cucumber fishery [1]. Reference [2] released guidelines for the world sustainable harvesting of sea cucumbers particularly Holothuria Scabra but not on other sea cucumber species. These guidelines have become laws in some countries, but many places don't have the resources to enforce the regulations.

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The desire for immediate action for conserving stocks biodiversity, ecosystem functioning, and resilience from other stressors is, therefore, a need in sustaining the ecological, social, and economic benefits of these natural resources and the impact of fishing in the oceans and coastal areas is a worldwide concern [2]. Sea cucumbers are frequently among the largest and most diverse classes of benthic invertebrates in the intertidal and sub-tidal and constitute the vast majority of total biomass in slope and abyssal benthic systems. These organisms inhabit sheltered shallow-water sediment in all tropical and temperate oceans, but their greatest abundance and diversity occur in the tropical Indo-Pacific region and they are widely distributed in all depths, adapted to live in a wide variety of habitats including rock, mud, and fronds of seaweeds. While most sea cucumbers are either sedentary or at least comparatively slow-moving, several species move periodically by swimming and a few are primarily bathypelagic free swimmers. As of 2013, only 38 sea cucumber species found in Ilocos Sur are categorized as commercial and non-commercial species. Most of these animals that are harvested are exported to Asian markets and reflect a delicacy. Actinophyga echinites are one of the species that is determined as medium value species. This is the only species eaten by Ilocanos and is commercially available in the local market.

The importance of conducting reproductive studies on Holothuroids is deemed necessary due to their important role in the conservation of our marine environment. Its economic importance and are used as food, they are also important members of the benthic communities responsible for causing significant changes in the composition of the floor. They have also medical importance which includes treating weakness, impotence, debility of the aged, constipation due to intestinal dryness, and frequent urination. Because of the demand, the collection of sea cucumbers to supply the market has seen a depletion of this resource in the traditional fishing grounds. Currently, there are fisheries harvesting sea cucumbers across most of the resource range, including remote parts of the Pacific. This global review shows that sea cucumber stocks are under intense fishing pressure in many parts of the world and require effective conservation measures. It also shows that sea cucumbers provide an important contribution to the economies and livelihoods of coastal communities, being the most economically important fishery and non-finfish export in many countries [3].

Knowledge of the gonad morphology of sea cucumbers is crucial to understanding their reproductive cycle. The gonad index method is a reliable technique for tracking reproductive maturity. Gonad tubule length and diameter have also been shown to be correlated with sexual maturity. Both indicated one spawning cycle during the summer period with maximum activity during June and July [4]. On the other hand, size at first maturity is also commonly used in almost every fishery in the world to establish a minimum capture size from which 50% of the captured animals are mature and have already gone through a reproductive period [5].

Since Actinophyga echinites are commonly found in Ilocos Region and the gathering is continuous regardless of considering size restriction, depletion of these species will be at risk in the future thus, this research was conceptualized. Determining the maturity stages of male and female, the gonadal maturity of the species and size at first sexual maturity form part as a basis in identifying the minimum size limits, the peak of breeding season which will be used in establishing management regulations to protect the reproductive potentials of the sea cucumber populations and to sustain and maintain production.

2. Materials and Methods

2.1. Site Selection and GPS Reading

The result of the interview conducted was used in determining the four sampling stations. The basis of site selection was dictated by the specific habitat of the species. Four sampling stations were set and measured using Global Positioning System (GPS) readings as determinants for permanent stations done every sampling period.

Narvacan Sta. Maria

Lat=170 26’ 45.85”N Lat = 170 22’ 36.54” N

Long=1200 26’31.20”E Long = 1200 26’ 55.89” N

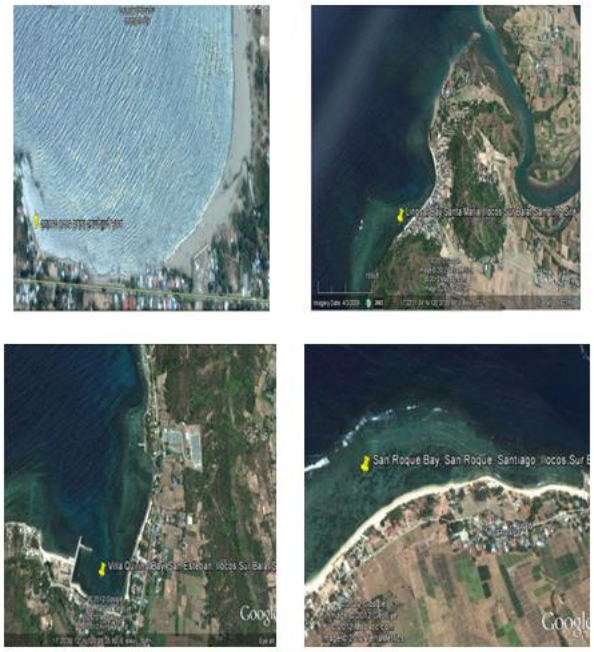

Figure 1: Specific Location of the Sampling Stations.

San Esteban Santiago

Lat= 170 20’ 27.61” N Lat = 170 16’ 37.14 N

Long= 1200 26’ 41.29” E Lat = 1200 25’ 16.10” E

2.2 Sampling

The species were collected in the four sampling stations of Narvacan, Sta. Maria, San Esteban and Santiago. Samples were taken monthly using the transect method. A total of 234 males and 180 females were collected. The collection of samples was gathered through the use of a transect line perpendicular to the shoreline measuring 100 meters long and a width of 2.5 meters on both side sides of the line. This was limited to the specific area and is done twice a month, one in the morning and the other in the evening.

2.3 In situ Morphological Determination

Sea cucumbers were placed in a plastic container containing water and 5% magnesium chloride. Before this, the samples were left to expand and extend their tentacles in seawater. All measurements were taken (length, weight, width) after the relaxation of the sample animals using an electronic weighing scale having 0.05 grams sensitivity. This was found to overcome errors resulting from the contraction and relaxation of the animal's body. The method was adopted and proved to be efficient [6]. The specimens were dissected to obtain gonad weight and gutted weight (body wall of the animal after removal of the viscera). The gonads-either male or female was fixed to 7% buffered formalin for a few minutes rinsed in tap water and stored in 70% ethanol [7]. Macroscopic and microscopic features of the gonad were used to assess/identify the maturity stages. Gonad color, thickness size, shape, length, and tubule diameter determine the different maturity stages.

2.4 Maturity Stages and GSI Determination

Four stages of maturity were determined for both sexes as follows: Immature (I), Maturing/Developing Stage (II), Ripe Stage (III), and Spent Stage (IV). Each of the sample gonads was examined and assigned the stages based on the macro and micro features. An eyepiece micrometer was used to measure oocyte diameter.

The gonado-somatic index (GSI) were calculated monthly both male and female A. echinites using the formula:

$$GSI = \frac{\text{weight of the gonad (grams)}}{\text{Gutted weight (grams)}} \times 100$$

Size at first sexual maturity was also determined by calculating the percentage frequency of both sexes in the study period and plotting the average length against the percentage of ripe individuals.

3. Results and Discussion

3.1 Monthly Distribution of Male and Female Maturity Stages

Figure 2 shows the monthly distribution of male maturity stages as immature, mature, ripe, and spent stages. This was observed in the laboratory before following the identification guide. Male sea cucumber A. echinites

occurrence was observed whole year-round with a peak during June to July and September to October. The immature gonad of male sea cucumber (A.e.) was observed partly whole year-round with a peak during June and October. The mature gonad of male sea cucumber (A.e) was detected partly whole year-round with a peak during July and September. The ripe gonad of male sea cucumber was also noticed whole year-round with a peak during April, May, June, and October. The spent gonad of male sea cucumber (A.e.) was detected partly whole year-round with July peak. The breeding observation occurred mostly every month. This observation was noticed that male sea cucumber (A.e.) reproduces monthly, however, a specific month of maturing stages as indicated falls within the warm months of July and September.

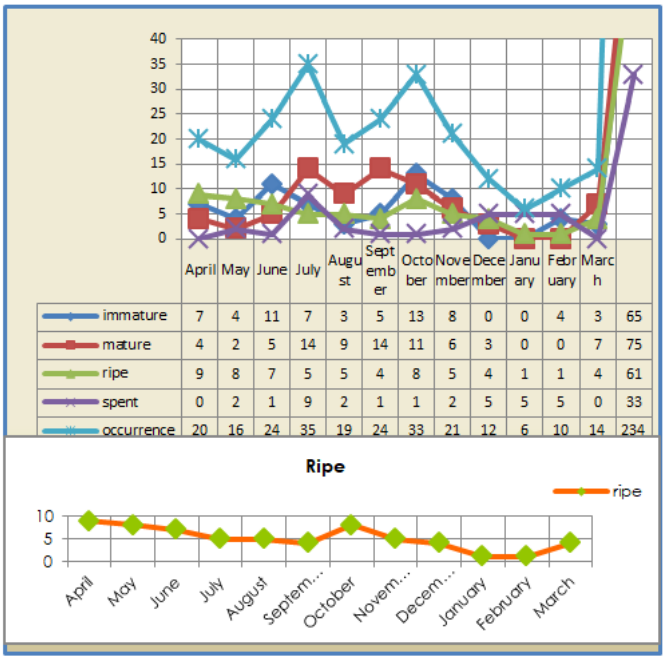

Figure 2: Male monthly gonad maturity stages.

The female gonad maturity stages of A. echinites as seen in the four different stations in Ilocos Sur. As witnessed, most of the ripe females were found between the month starting April, May, August, October, January, and March. Immature stages on April, July, September, and December. The spent stage was observed in February and December. The results acquired from the current study showed that sea cucumber (A. e.) spawning occurs every month. The spent gonad of male sea cucumber (A.e.) was observed partly whole year-round with July peak month. However, the maturity stages of both males and females are almost similar. The resting season appears from May to June and a major spawning season from November to March. This study concurs with [8], that the presence of mature individuals all year round could be baseline information for the aquaculture of this species, which presently gets a medium-good price on the trepang markets.

It is also attested that the spawning period is prominent in the temperate zones like the Mediterranean, where seawater temperature significantly varies between regions [9;10;11;12]. Considering the limited mobility of sea cucumbers, it is important to define the region-specific reproductive biology including gonadal development and spawning periods.

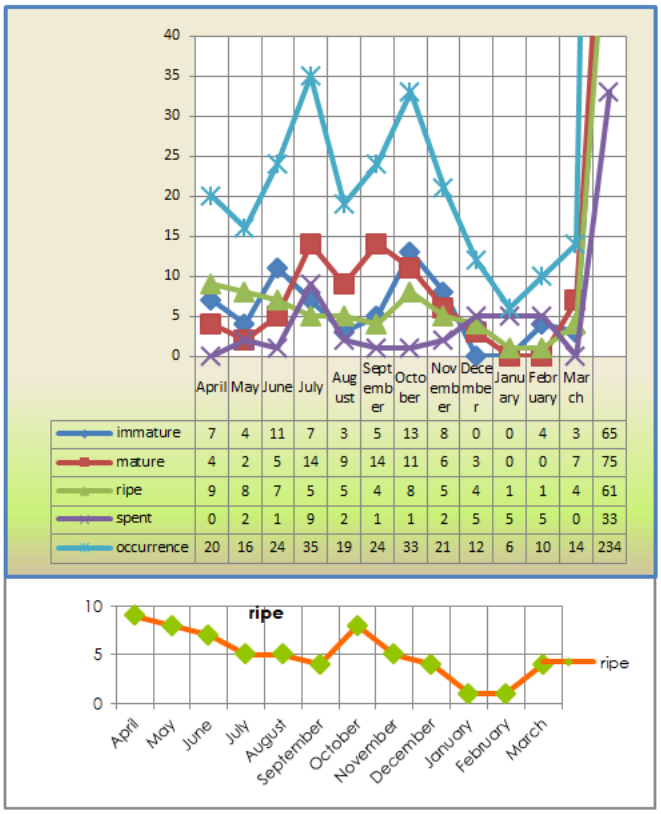

Figure 3: Female monthly gonad maturity stages.

3.2 Ganado-Somatic Index of Male and Female A. echinites in four sites

The monthly distribution of gonad index (GSI) for males (A. echinites) during the period of the study showed an increase from March to April with a peak in May then decreased monthly until November and increases gradually in December.

Table1: Male Monthly Gonado- Somatic Index of A. echinites in four sites.

Month	Narvacan		Sta. Maria		San Esteban		Santiago		Total	
	F	GSI	F	GSI	F	GSI	F	GSI	F	GSI (ave)
April	8	15.13	4	13.28	4	22.75	4	18.80	20	**17.90**
May	6	20.65	3	17.33	2	12.32	5	24.78	13	**18.77**
June	3	5.71	6	6.10	7	11.09	9	12.39	19	8.82
July	9	5.81	8	6.45	7	5.58	11	6.80	35	6.16
August	5	8.61	6	5.85	2	5.39	6	6.02	18	6.47
September	6	2.83	4	6.09	7	4.26	7	9.09	22	5.57
October	12	3.38	12	7.29	4	1.78	5	9.83	33	5.56
November	5	5.68	5	5.68	6	5.61	5	11.34	21	7.08
December	3	7.24	4	8.84	2	21.89	3	9.75	12	11.93
January	1	7.55	2	10.73	1	8.88	2	5.20	6	8.09
February	2	9.34	1	2.10	3	12.65	3	14.51	9	9.65
March	2	10.11	3	8.74	5	13.73	4	8.63	14	**10.30**
Total	62		58		50		64		234	

The gonad index monthly distribution appeared to a significant increase starting from March to April with a peak in May but slightly decreases monthly. The lowest GSI was only observed alternately in September, November, and January. This further proves that ripe males and females A. echinites attained a synchronous peak of development and were also found all year round with its distinct period of activity as indicated by an increase and decrease pattern of gonad development. This coincided with the study of [13] who stated that the reproduction process of sea cucumber (Holothuria scabra) research culminated full especially in May.

A. echinites attained a synchronous peak of development in both sexes and were also found all year round with its distinct period of activity as indicated by an increase and decrease pattern of gonad development, however, an increased pattern from March to April with a peak in May then decreased monthly until November. The same result was also indicated that the GSI of H. scabra varies from one place to another [14,15]. The highest peak of the cycle, GSI occurs at the full moon cycle in May rather than the new moon in which the highest value occurs in May. The usefulness of knowing the gonado-somatic index was to determine the changes that happen in the gonads quantitatively so that time can be presumed spawning [16,17].

Table 2: Female Monthly Gonado- Somatic Index of A. echinites in four sites.

Month	Narvacan		Sta. Maria		San Esteban		Santiago		Total	
	F	GSI	F	GSI	F	GSI	F	GSI	F	GSI (ave)
April	3	20.83	4	11.73	3	33.57	4	49.2	14	**28.83**
May	3	26.33	3	42.51	1	66.70	3	56.10	10	**47.91**
June	2	7.465	1	5.73	5	30.98	4	20.25	12	16.11
July	8	9.30	15	6.86	7	22.94	12	7.38	32	11.62
August	1	23.33	5	11.57	4	5.82	1	8.69	11	12.35
September	4	8.755	4	6.13	6	8.52	9	7.03	23	7.61
October	4	7.645	6	13.11	3	12.39	7	8.10	20	10.31
November	6	12.615	2	1.69	3	5.31	7	11.59	18	7.80
December	2	21.22	1	3.13	6	16.17	3	12.37	12	13.22
January	1	0.53	2	2.20	3	21.19	3	15.51	9	9.86
February	3	10.16	2	3.16	2	14.18	1	17.59	8	11.27
March	3	30.66	1	24.67	4	19.54	3	18.71	11	**23.395**
Total	40		36		47		57		180	

3.3 Size at First Male and Female Sexual Maturity

The size at first sexual maturity was determined for each sex by estimating the percentage frequency of ripe males and females of A. echinites in one-year samples and plotting the average total length against the

percentage of ripe individuals. The observed size at first sexual maturity of the individuals during the period of study was 9.17 cm for males and 10.28 for females. The size of females when maturing is bigger (10.28 cm) as compared to males (9.17 cm), an indication that harvesting of sea cucumber A. echinites be restricted within that specific measurements to reproduce first before it will be harvested. Other research results mentioned that the size at sexual maturity for H. Mexicana between 13-15 cm and its maximum reproductive activity between May-July, rt when the temperature was 2 °C above the annual average and 3-4 °C higher than the lowest monthly average [18]. Though different species of sea cucumber found in a specific location and sizes differ, the size at first sexual maturity usually identified specific sizes to reproduce before it will be harvested/extracted. As mentioned, the size at first maturity is necessary to manage capture sizes [19;8] which has a biological justification in maximizing the yield per recruit and allowing individuals to spawn before harvest, and also an economic reason as larger individuals command a better price than smaller ones. Smaller sea cucumber when gathered earlier, depletes the natural stock. This is again attested by [20] states that seasonal closure using results on the spawning season during warm water period and minimum size at 1st sexual maturity are tools for enhancing sustainable management in fisheries. Finally, [21] recommends the use of minimum harvesting size for female sea cucumbers to mature. This could be utilized to reduce fishing pressure during peak reproductive times to allow aggregation of individuals and successful reproduction [22,23] could also be used as a guideline to establish minimum capture sizes for fisheries or by establishing local management regulations to protect the reproductive potentials of populations

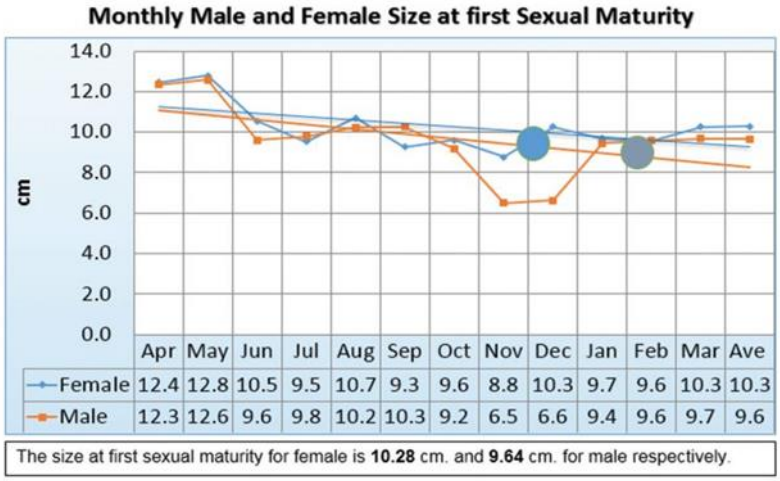

Figure 4: Male and Female Sizes at First Sexual Maturity.

4. Conclusion

Maintaining and sustaining sea cucumber (Actinophyga ethnicities) for fishery resource management, size restriction of 9.17 centimeters for males, 10.28 centimeters for females, and closure during the peak breeding season in May. The catch size and minimum size limits should be introduced and enforced in areas with a high abundance of commercial species.

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