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Biological Inputs to the Management of Tabagwang (*Jagora asperata*) in Buradan River Viga, Catanduanes, Philippines

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Abstract

Jagora asperata (Lamarck, 1822) known to Bicolanos as *tabagwang* is an edible mollusc species thriving in rivers of the Bicol region. It is being harvested and cooked in coconut milk mixed with edible fern. There is a dearth of information regarding its biology and fishery in the Bicol region. This absence of information necessitated this study. The study was conducted in Buradan River, Viga, Catanduanes, from January 2013 to May 2014. Spatial distribution of the species was observed to be a clumped distribution (mean index of aggregation is 0.03). There were 28,921 individuals gathered: the average length is 40.14 mm and average weight is 4.57 g. The length-weight relationship was obtained as $W = 0.00025 \times L=2.624$. The estimated length-at-first maturity was 32.04 mm for females and 33.64 mm for males. This species exhibits ovoviviparity as the mode of development. The distribution of the sexes is 1:1. Gonado-somatic index is highest in the months of October and December. The estimated population param were: $L\infty = 71.26$ mm, $K= 0.39$ year^{-1},$Z= 1.85$ year^{-1}; $M= 0.69$ year^{-1}; and $F= 1.16$ year^{-1}. Exploitation rate is 0.63. The estimated MSY/R is 6.53 g per recruit, corresponding to a length of 48.29 mm, and the F(MSY) is 3.5 per year. The results showed that the population of *J. asperata* is overexploited and overfished, and management policy must be implemented for the stock to recover.

Keywords: *biology, Catanduanes, Jagora asperata, management, tabagwang*

Introduction

The Mollusca is an extraordinary phylum, having repeatedly and successfully colonized both land and water habitats. There are around 100,000 described species, and they are second only to arthropods in species richness. The largest molluscan classes are the Gastropoda and Bivalvia. One of the colonizers of fresh water belonged to family Pachychilidae, and under it, the superfamily Cerithioidea. Cerithioideans are pantropically distributed and of great ecological importance as grazers and detritus feeders in most tropical to subtropical aquatic ecosystems (Köhler & Glaubrecht, 2002). Under this group is *Jagora asperata*.

J. asperata is restricted to the northern part of the Philippine archipelago, as well as to Panay, Leyte, and Samar (Köhler & Glaubrecht, 2002). In their study, the materials they examined came from Camarines provinces and in Albay, but they did not mention Catanduanes. However, in their map, they indicated the presence of the species in Catanduanes province. Köhler and Glaubrecht's (2002) work was the only available reference that described the said species, in terms of morphology, reproductive biology, and molecular genetics.

This gastropod is well-known (locally known as *tabagwang*, in some areas, it is called *suso*) in the Bicol region, Philippines, in which they are utilized as a source of income as well as for culinary purposes. This species is considered a delicacy in many parts of the region, mainly because it is believed to have nutritional value especially for breastfeeding mothers. In addition, it is commercially recognized and exploited for subsistence purposes. Ecologically, they serve as food to other invertebrates and fishes. Likewise, they eat decaying organic matter and some bryophytes like mosses which abound on riverbanks.

Regular collection of this organism is verified in several municipalities of the region. Previously, some areas have plenty of this species, but now the local folks are saying that it is no longer present in their areas. The population of *J. asperata* is now threatened and at risk

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of collapsing due to anthropogenic activities, such as unregulated collection. The absence of extensive study conducted in the region with regards to the information on the biology and fishery of the species necessitated this study.

The general objective of the study is to establish information on the biology and fishery of *tabagwang* (*J. asperata*) in the river of Catanduanes. Specifically, the study aims to determine the physicochemical param of the river through temperature, speed of water current, pH, water depth, and turbidity; the type of distribution and density; biology in terms of length-weight relationship and reproductive biology; and its fishery in terms of growth, mortality rates, exploitation rate, virtual population, and maximum sustainable yield.

Materials and Methods

The collection of samples was conducted in the province of Catanduanes (Figure 1) from January 2013 to May 2014. It is an island province in the Bicol region, situated on the northeastern part, facing the expanse of the Pacific Ocean. The topographical feature of the said province is mountainous, with extensive long chain of mountain ranges, and is bestowed with fresh flowing streams and river waters. The river system in Catanduanes provides a very suitable habitat for vertebrates and invertebrates animals, including *J. asperata*. The province was chosen as the sampling area because there is a regular collection and market of this organism especially in the municipality of Viga. Data collection was made at Buradan River located in Barangay Summit of the said municipality. The sampling stations measured 1,000 m in length and 10 m in width on the average.

The first station was located downstream at the junction of Tagutong and Buradan rivers. It ended near the end of the barangay road. Station one was meandering and there was vegetation along its banks which were possible sources of food of *J. asperata*. Rocks and boulders were present along the river and sometimes obstructed the flow of the river creating strong currents. Ferns were notable along its riparian zone. The second station was located in front of the barangay road and ended 1 km upstream. The second station appeared similar to the first station, but the flow of water in some parts of the river slowed because there were no boulders and rocks that obstructed its natural flow. Also, vegetation was present in its riparian zone. Abaca and giant ferns found in Station 1 riparian zone were present also in Station 2.

The third station was located a km away from the barangay road and also upstream. The third station also has boulders and rocks within its river. The riverbank was colonized by vegetation, notably ferns and dipterocarps. The fourth station was located 2 km away from the barangay road and further upstream. In the fourth station, very big boulders were present that one had to climb over to reach the other part of the river. Water would cascade downstream from the fourth station. Abaca and fern plants were observed to be present along the banks of all stations. Within the established stations, collection of specimens was undertaken. This was done through visual identification of the target species and by upturning rotting leaves that have fallen and accumulated along the banks of the river. Boulders and rocks were observed for the presence of target species. Collected individuals were

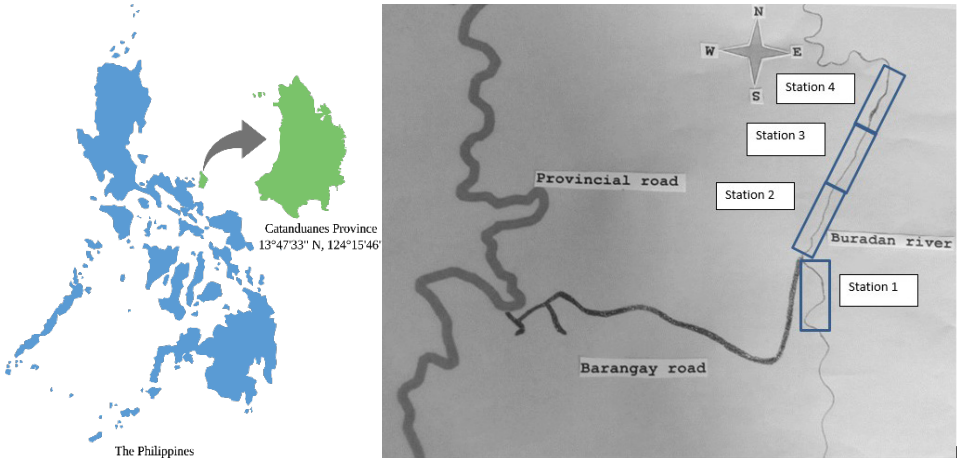

Figure 1. Catanduanes island (A) and sampling area (B)

measured for their length using a calliper and the weight using a digital weighing scale.

Sufficient arrays of samples were collected and they were measured and recorded separately for their length (in mm) and weight (in g) from each sampling trip per month. Length-weight relationship was estimated using regression analysis. Four identified stations were assessed for the ecological param such as the physicochemical param of water, type of spatial distribution, and the density.

For the reproductive biology analysis, 30 pieces of *J. asperata* were dissected and the gonads were extracted. Likewise, the gonadosomatic index (GSI) was established, as an index of gonadal activity, and as an index for spawning preparedness (de Vlaming, *et al*, 1982).

Lastly, growth param, mortality rates, exploitation rates, virtual population (cohort) analysis, and yield per recruit were estimated based on the analysis of the length data collected using methods of stock assessment, programmed in the computer. R was used for statistical analyses (R Core Team, 2015).

Results and Discusssion

External structure

A highly turreted shell, sculptured by axial ribs and spiral striation characterizes this species. Axial and spiral elements in some specimens form spiny nodules at their junctions (Köhler & Glaubrecht, 2002). The collected individuals comprises four to eight whorls, the average of which is 5.4. The color of the shell ranges from light brown to dark brown (Figure 2).

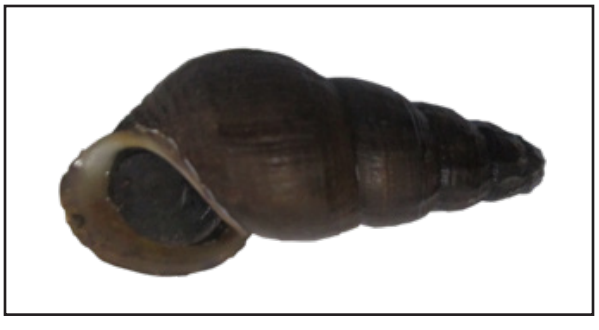

Figure 2. *J. asperata*

Ecology

This species thrives in clear and cool waters, and the local folks strongly state that this species can only be seen thriving in the said water condition. This remark was verified during the sampling periods in the river. The acknowledgment of the local knowledge and the result of the physicochemical measurements of the water quality complements the presence of the species in the area. Aquatic organisms, such as this freshwater gastropod, are particularly useful to determine the quality of the water with respect to its suitability for aquatic life (Chapman, 1996), therefore the presence of this organism is an indicator of a clean and non-polluted water. There was a one-time sampling of the physicochemical param whose purpose was to give a general description of the said param. Table 1 shows the result of the measurements.

Table 1. The result of *in situ* physicochemical measurements.

Param	Result
Temperature	23°C
pH	6
Turbidity	0
Water depth	39 cm
Water current speed	0.44 m/s

Another notable observation is that this organism can be found near the riverbank because decaying organic materials are found settling in this part of the river where they can hide and source out their food. They are micro-herbivores but would also feed on other macro-benthic flora. Some of the individuals are partly buried in the riverine substrate, some clinging on stones near the riverbank, while others attached to decaying plant debris.

In terms of distribution, this species exhibits a clumped type of distribution (the average index of aggregation is 0.03). This result indicates that the resources such as food needed by *J. asperata* are also clumped in occurrence. The tendency of the species is to converge in the area that is plentiful in food resulting in a clumped distribution. The nearest neighbor analysis was used to determine what type of distribution this species showed.

The analysis of weights of the species per station showed that there was a significant difference ($p < 0.05$)

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between the four stations. Implementing the Tukey test, it showed that the difference was significant in Station 4, which is located about 3 km away from the first station and located upstream. The weights of the individuals collected in this area were lighter compared to the other three stations. It can be perceived that (a) bigger individuals tend to locate downstream and (b) more food is located downstream. Likewise, the unidirectional and unequilibral characteristics of the river may allow for bigger individuals to locate downstream. In terms of density, there were no significant differences among the four stations ($p > 0.05$). This finding indicated that clumped distribution occurred in all the sampling stations.

Length-weight Relationship

There were 28,921 individuals of *J. asperata* collected. Mean length and mean weight ranges from 36.77±8.17 to 43.45±7.09 mm and 3.68 ± 2.31 to 5.76 ± 2.62 g, respectively. The length-weight relationship (Figure 3) can be summarized as $W = 0.00025 \times L=2.624$ ($r = 94.9\%$) and examining the b value will show that the growth of *J. asperata* is allometric, in a sense that there are "changes in relative dimensions of parts of an organism that are correlated with changes in overall size" (Gayon, 2002). The samples in all four stations were lumped together for this analysis because it was safe to assume that the samples belonged to the same stock since the island province is isolated from other landmasses. It is surrounded by bodies of seawater preventing migration of other stocks.

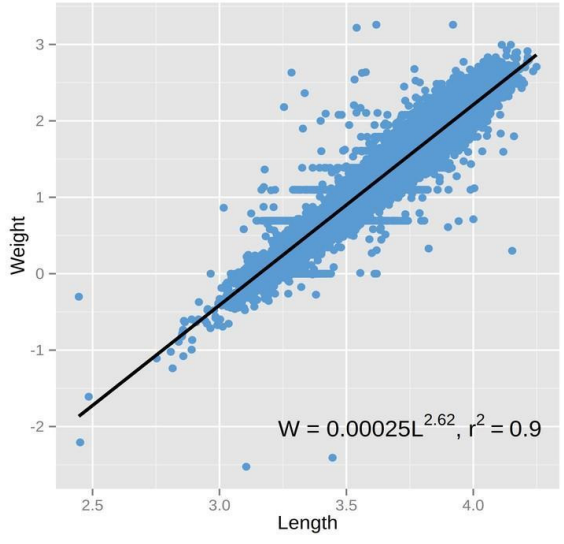

Figure 3. The length-weight relationship of *J. asperata* collected in the sampling area

It was noted that the computed value of b falls within the expected range of b value of 2.5 to 3.5. The parameter ($b < 3.0$) means that large specimens have changed their body shape to become more elongated or small specimens were in better nutritional condition at the time of sampling (Froese, 2006). The significant change in body proportions of this species can be explained by the presence of exoskeleton or external hard covering, and the coiling of this structure tends to cause elongation of the body. In addition, Charlander (1977), as cited by Froese (2006), demonstrated that values of $b < 2.5$ or > 3.5 are often derived from samples with narrow size ranges. The result of the study showed that $b = 2.6$, indicating that almost the collected individuals encompasses a wide range of lengths. It can be also confirmed in the histogram of length frequency distribution below (Figure 4).

The samples collected nearly follow a normal distribution. In addition, the graph showed that the majority of the catches are from 36 to 48 mm, which comprises about 48.33% of the total catch.

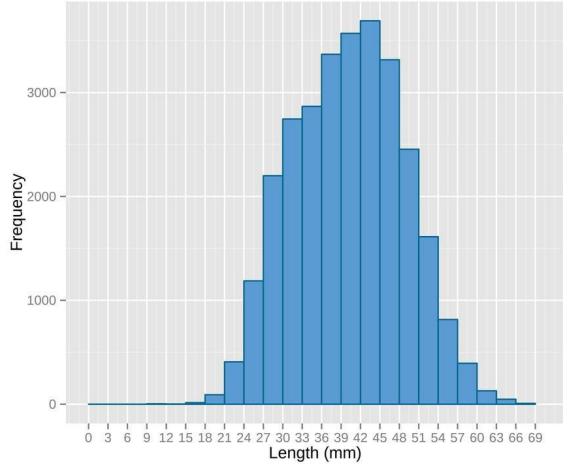

Figure 4. Length distribution of *J. asperata* in Buradan River.

Reproductive biology

J. asperata have a single and conical gonad located in the posterior spiral part of the shell. Gonadal tissue is located over the digestive gland and is in intimate contact with it. Male gonads exhibit pale yellow to dark yellow coloration, whereas females were characterized by pale to creamy white coloration (Figure 5). This coloration is also observed in the prosobranch gastropod *Thais carinifera* (Radwan *et al.*, 2009).

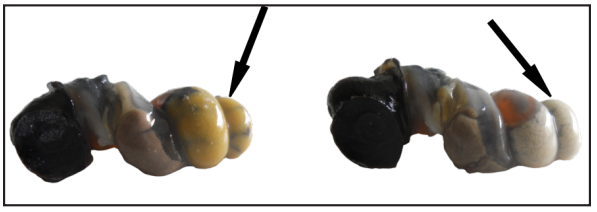

Figure 5. Male (left) and female (right) *J. asperata* showing the location of the gonads and its coloration.

The estimated length-at-first maturity was 32.04 mm for females and 33.64 mm for males. It can be noted that there were collected individuals below the estimated length-at-first maturity, which is about 25.33% of the total number of collected individuals, indicating that the collectors did not filter the small individuals during their activity. Therefore, even the immature individuals experience the same collection pressure as the adult individuals. In addition, this species exhibited ovoviviparity (Figure 6) as the mode of development. Several authors agreed that gastropods belonging to family Pachychilidae, in which *J. asperata* was grouped, exhibits ovoviviparity (Glaubrecht, 1999; Köhler *et al.*, 2004; Rintelen, 2010; Gomez *et al.*, 2011). Likewise, Kohler and Glaubrecht (2002) described the species as ovoviviparous. As observed, there were shelled juveniles or young *J. asperata* seen inside the body of the mother.

This may support the assumption that this species shows evidence of being ovoviviparous, in which "females retain egg capsules, developing embryonic and juvenile stages within the mantle cavity" (Köhler & Glaubrecht, 2002).

Figure 6. Female *J. asperata* showing ovoviviparity as mode of development.

Sex ratio and gonado-somatic index

The distribution of the sexes in the population is 1:1 (p-value> 0.05), that is, one male to one female ratio. Of the analyzed specimens, 208 of which were males and 241 were females.

Gonado-somatic index (GSI) of *J. asperata* is fluctuating through the months (Figure 7), and showed that both males and females have a harmonized development of gonad. It also showed that during the months of October to December that this organism has a high average GSI, which indicates that spawning occurred in these months.

Reproductive cycle of *J. asperata* is synchronized with the seasonal changing monsoon climate, and its reproductive activity is clearly restricted to the rainy season in Luzon between June and December (Köhler & Glaubrecht, 2002). This situation was verified in the population in Catanduanes, wherein there are two highest peaks of gonadal maturity shown—the months of October and December—that represent the time or seasons of spawning. Northeast monsoon (*amihan*) occurs during these months, carrying rain to the region as it moves in its path.

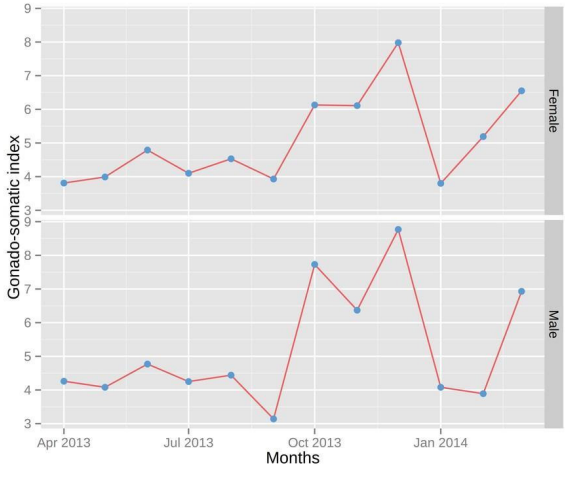

Figure 7. Gonado-somatic index of *J. asperata* collected in Buradan River showing the two highest peaks—October and December—that indicates spawning period.

Population parameters

The estimates of the growth param using the Powell-Wetherall method (Table 2) revealed that L ∞ = 71.26 mm, K= 0.39 year^{-1}, and the Z/K is 4.26 (Figure 8A). The K value indicates that this species is a slow growing organism. Total mortality rate (Z) is 1.85 year^{-1}; natural mortality rate (M) is 0.69 year^{-1}; and fishing mortality (F) is 1.16 year^{-1}. Exploitation rate yielded a value of 0.63 indicating that such species is being overexploited (Figure 8B).

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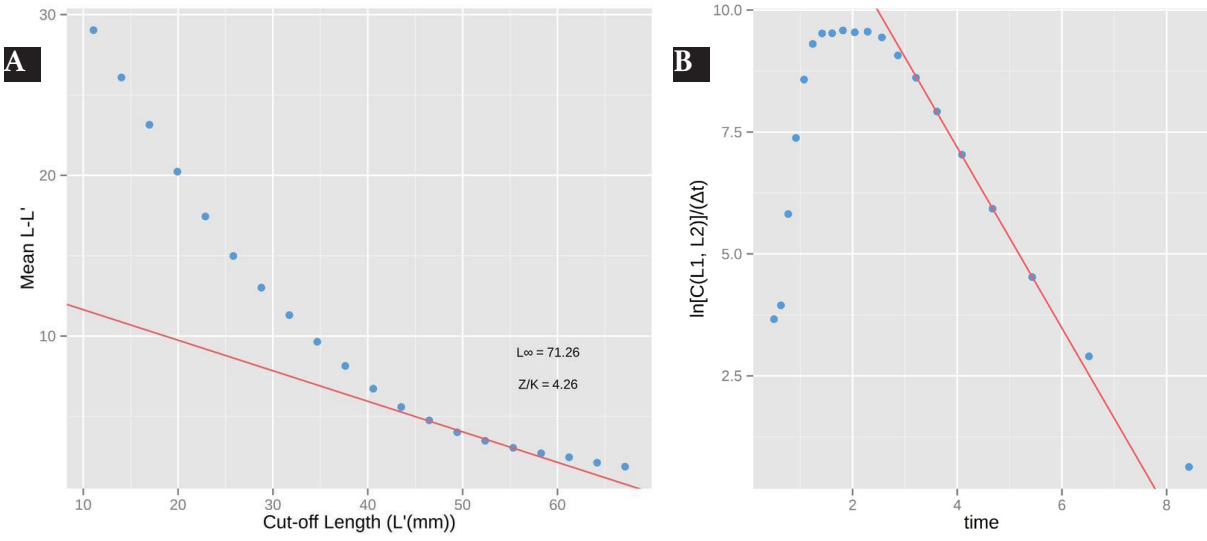

Figure 8. (A) Powell-Wetherall method to estimate the L∞ of *J. asperata* and (B) Length-converted catch curve to estimate the fishing mortality and the exploitation rate of *J. asperata* in Buradan River.

Table 2. Powell-Wetherall method for estimating L∞

Length interval L1 - L2 (x) = L1	Number Caught C(L1, L2)	Mean length of fish longer than L'L	L - L (y)	Remarks
11.08-14.02	5	40.11	29.03	Not used in the analysis
14.0316.97	7	40.12	26.09	
16.98-19.92	48	40.12	23.15	
19.93-22.87	242	40.16	20.23	
22.88-25.82	752	40.32	17.44	
25.83-28.77	1886	40.81	14.98	
28.78-31.72	2509	41.79	13.01	
31.73-34.67	2712	43.03	11.30	
34.68-37.62	3114	44.32	9.65	
37.63-40.57	3273	45.77	8.14	
40.58-43.52	3653	47.30	6.72	
43.53-46.47	3616	49.11	5.58	
46.48-49.42	2817	51.23	4.75	Used in the analysis
49.43-52.37	2040	53.44	4.02	
52.38-55.32	1192	55.86	3.49	
55.33-58.27	595	58.38	3.05	
58.28-61.22	247	60.98	2.71	Not used in the analysis
61.23-64.17	82	63.68	2.46	
64.18-67.12	25	66.30	2.12	
67.13-70.07	6	69.00	1.87	

Harvesting by collectors focused predominantly on easily accessible individuals, though there are some who gather in deep areas of the river. Since the type of distribution of this species is clumped, they can easily be found and exposed to overexploitation. The approximate mean length that is collected is 36.15 mm. It can then be inferred that the majority of the species caught (≥ 42.05 mm) already contributed to the population. But it is also noted that size classes less than the sizes at-first maturity (< 30 mm) were also harvested. Thus, immature individuals already are experiencing fishing mortality. Therefore, this might affect the spawning and recruitment success of the population over time, and the risk of population decline.

The occurrence of overexploitation is possible since the fishing mortality rate is higher as opposed to the natural mortality rate, suggesting that most of the individuals experience mortality due to collection of humans instead of natural way such as old age, disease, and/or predation. It is further supported by the value of exploitation rate calculated (E = 0.63), which suggests overexploitation.

There were two cohorts identified in the population of the *J. asperata* in the river of Buradan, Viga. Battacharya's method was used to determine and separate normal distributions, each representing a cohort, from the overall distribution (Sparre & Venema, 1998). The mean length of the first cohort is 30.89±4.42 mm, whereas cohort 2 has a mean length of 44.36 ± 6.76 mm (Figure 9).

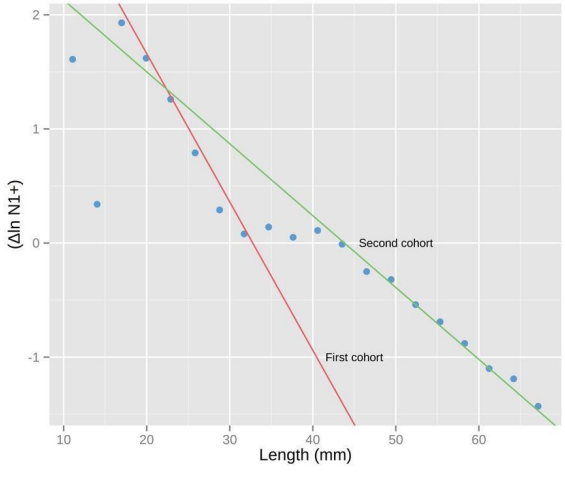

Figure 9. Battacharya plot to estimate the number of cohorts present in the population.

Though the population has two cohorts, both will suffer from the same fishing mortality and exploitation rate, since the collection doesn't only favor the other cohort. They live in the same river and will be subject to the same intensity of collection.

In addition, Maximum Sustainable Yield as a function of fishing mortality, F (MSY), was estimated using yield per recruit model developed by Beverton and Holt (1957). The estimated MSY/R is 6.53 g per recruit, corresponding to a length of 48.29 mm, and the F(MSY) is 3.5 per year (Figure 10)

J. asperata seems to be impacted in a way that almost every day collection takes place. If the collection activity is not regulated, resulting in increased fishing mortality, the exploitation of the species will eventually be affected, causing the optimum sustainable yield to be reached in a short period of time. If this happens, there will be an occurrence of growth overfishing.

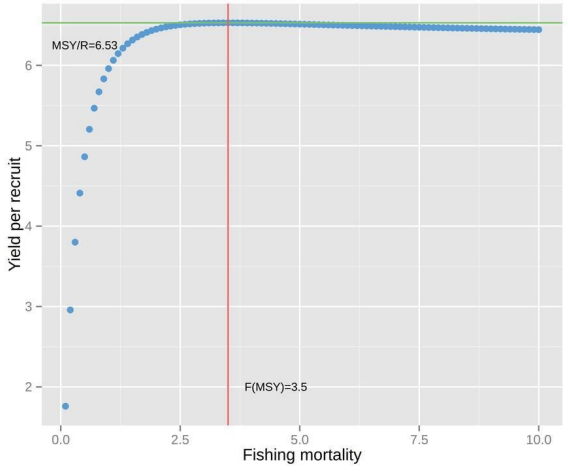

Figure 10. Maximum sustainable yield as a function of fishing mortality showing the estimated MSY/R and F(MSY) for *J. asperata* population in Buradan River.

Conclusion and Recommendations

This study successfully estimated the biology and population param of *J. asperata*, which has never been reported before. In addition, the current condition of this species was also established. The population of *J. asperata* in the river of Viga, Catanduanes, is on the verge of declining due to regular collection, especially in rivers that are near residences. The state of the organism is exploited, and therefore, would result in the disappearance

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of the species in the area if unregulated collection is maintained. Collection is non-selective in a sense that even smaller individuals are collected (< 30 mm), and these sizes do not yet contribute to the population. The need to implement the recommendations is justifiable so as to improve the population.

The river system is very important for freshwater organisms' survival and activities. The effect of the disturbance in any part of the system can be experienced in the whole body of water. Human activities can induce the effect if there is no regulation of anthropogenic activities that destroy the systems. The study conducted might be helpful to appreciate the importance of the species and its contribution to the environment, as well as to their economic activities. Generation of policy regarding the protection of the river systems as well as the aquatic organisms, including *J. asperata*, may be possible since there is data to backup policymakers in their decisions. Although government interventions may be a success, the will of local residents to preserve resources is still the most effective way to maintain the population of *J. asperata* and reduce the level of exploitation. This study will also create awareness regarding the biology of the target species, especially its spawning seasons. This is very helpful to maintain the population of this species.

Caterall and Poiner (1987) demonstrated that gastropods are not fully reproductive at the size of first maturity. Since immature individuals were already collected, and the growth rate is very slow, it is thus recommended to:

1. Collect only individuals with a length of 37 to 45 mm. At this length, it is assumed that it already contributed to the recruits. Gleaners should bring a measuring stick equivalent to the recommended length to avoid mistakes in collection.

2. Implement a close season during the month of December in Buradan River. The yield can be improved over time since the closure will increase the egg production and eventually the recruits.

3. Establish a sanctuary in the nearby river, Tagotong River. Implementation of sanctuary in the selected river will also help in propagating the said resource. The sanctuary will start in the first waterfall of Tagotong River up to the junction of Buradan River.

4. Investigate other rivers of the municipality and other municipalities for the presence of such species to compensate for the closure of Buradan River during the peak of spawning.

5. Reforest the riparian zone of the river to reduce the rate of erosion. Conversion to abaca plantation of the zone should be discouraged. Rather areas away from the zone should be planted with abaca.

6. Increase tilapia production in the said river so that fishers in the area can have other catch instead of the usual *J. asperata*. This can be done in coordination with BFAR.

A copy of this report was given to the Local Government of Viga, Catanduanes for their consideration and as the basis for management implementation for the recovery of the population of *J. asperata* and to have a sustainable utilization of the said aquatic resource.

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