Journal of Natural and Allied Sciences
Vol. V No. 1, pp. 1-9, January – December 2021

Size Structure, Meat Yield, Condition Index and Shell Dimension-Weight Relationships of Freshwater Bivalves from the Water Impoundments of Pampanga State Agricultural University, Magalang, Pampanga

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Abstract - An assessment was carried out to determine the status of exploitable freshwater bivalves from the water impoundments of Pampanga State Agricultural University in terms of their size structure, meat yield, condition index and the relationships of shell dimensions to the weight. A total of 150 samples were collected from each bivalve species and subjected to morphometric and gravimetric measurements. Results revealed that sizes in terms of mean shell length of *Corbicula fluminea*, *Pilsbryoconcha exilis* and *Cristaria plicata* were 32.04 mm, 30.55 mm and 68.59 mm, respectively. Meanwhile, the bivalves were having a mean of 22.68 g, 26.16 g and 228.54 g as to their live weight. With regard to meat yield, the bivalves showed 32.48%, 28.71% and 36.94%, respectively. The condition indices of bivalves were 22.50 (*C. fluminea*), 19.16 (*P. exilis*) and 35.63 (*C. plicata*). Moreover, the bivalves exhibit negative allometric growth. Based from this result, the bivalves are not suitable for harvest during the period of the study.

Key words: Size structure, meat yield, condition index, shell dimension, live weight

INTRODUCTION

Bivalves are a very important part of biodiversity playing major roles in freshwater ecosystems [1-2]. They play an important role in nutrient cycling and filtering organic matters suspended in water. Their waste materials are deposited in the substrate where the nutrients are used by marine macrophytes and algae. They are also preyed upon by other species, such as shorebirds, fishes and crustaceans [3]. They are known to be of high nutritional value since they are good sources of protein [4], calcium and other nutrients [5].

It was reported that bivalves are commonly utilized as protein source particularly by riverine and lake communities as replacement for expensive sources such as poultry and livestock meat products [6]. In Southeast Asia, freshwater bivalves are regularly collected for home consumption and its fishery is part of the so-called “subsistence fisheries” [7]. Bivalves are also common inhabitants of freshwater environments such as lakes, rivers, ponds and swamps in the province of Pampanga. The province is among the top aquaculture producers in the country. One of the aquaculture areas in the province is the municipality of Magalang where Pampanga State Agricultural University (PSAU) is situated. The university caters different freshwater species including tilapia, freshwater prawn and catfish.

Three species of edible bivalves are present in the water impoundments of PSAU which include *Corbicula fluminea, Pilsbryoconcha exilis* and *Cristaria plicata.* However, identification was only based on shell morphology and comparison with published information. Verification is highly indispensable using molecular techniques in particular. These bivalves are harvested and prepared as food by local communities. Populations of these species may have successfully adopted to the climatological and limnological setting of freshwater ponds in the locality as observed in their abundance. However, they are sometimes considered as nuisance in tilapia production due to their ability to compete for dissolved oxygen and infest the fish during the early stage of their life cycle. The populations of these resources in the locality are not frequently exploited for table consumption; hence, these populations are not yet experiencing heavy pressure. However, study on their growth pattern and biological condition was not yet considered. Thus, an assessment must be carried out in order to have basis for the exploitation and sustainability in future product development undertakings. The study aimed to determine the size structure, meat yield, condition index and shell dimension-weight relationships of freshwater bivalves from the water impoundments of Pampanga State Agricultural University.

MATERIALS AND METHODS

The study was carried out to three groups of freshwater bivalves Samples of *C. fluminea, P. exilis* and *C. plicata* were taken (regardless of size) from the water impoundments of Pampanga State Agricultural University. A total number of 150 samples were randomly collected from each group by scraping and handpicking. All samples were brought to the laboratory and individually measured.

Fig.1. *C. fluminea.*

Fig. 2. *P. exilis.*

Fig. 3. *C. plicata.*

The shell dimensions including shell length (SL), shell width (SW) and shell depth (SD) were measured using a digital Vernier caliper while weight measurements which includes live weight (LW), wet shell weight (SW), dry shell weight (DSW), soft tissue weight (STW) and dry soft tissue weight (DSTW) were done using a digital weighing balance with 0.01 g sensitivity [8]. Meanwhile, the internal shell cavity capacity of bivalves was computed by subtracting DSW from STW [9]. The minimum, maximum and mean sizes for each species were recorded.

Important parameters such as meat yield, condition index, length-weight relationship and test of significance for "b" were computed using the following formula:

Meat Yield (%) = Wet weight of meat/ weight in shell x 100% [10]

Condition Index (Ci) = dry meat weight x 100/dry shell weight [11]

Length-Weight Relationships: log W = log a+ b log L [12]

Test of Significance for 'b': $t = (b-3)/s_b$ where, $S_b = \sqrt{(\sum x^2 - (\sum x)^2/n)/n-1}$ [13]

RESULTS AND DISCUSSION

Size Structure

Table 1 presents the size structure of *C. fluminea* in the impoundments of PSAU. A total of 150 *C. fluminea* with shell lengths (SL) ranging from 10.10 to 49. 50 mm with a mean length of 32.04 mm and a shell width (SW) ranging from 21.60 to 50.00 mm with a mean of 37.10 mm were measured during the sampling period. The *C. fluminea* collected from Sungai Pergau at Gunung Ren, a recreational spot has lower shell length (11.0-12.5 mm) distributions compared to the recorded lengths in this study [14]. Based from the analysis of specimens worldwide, the species can grow to a maximum shell length of 50.0-65.0 mm but usual sizes are less than 25 mm [15]. The shell length of the species has been regarded as important indicator of the age of individuals in the population [16-19]. Moreover, it has been reported that individuals that have reached the size of 7.5 mm are already sexually matured [19].

The minimum and maximum live weight (LW) of *C. fluminea* is also presented in Table 1. The results revealed that the live weight of individuals ranges from 2.80 to 55.13 grams. Wet shell weight and dry shell weight were having a mean of 7.94 g and 5.16 g, respectively. As to the mean soft tissue weight and mean dry soft tissue weight, the species recorded a mean of 3.81 and 1.03. When it comes to internal shell cavity capacity, a mean of 17.52 was recorded. Several factors could affect the weight of *Corbicula* [20]. Decrease or increase on the weight of the species may be due to the food concentration present in the environment [21], temperature, [22] and reproduction [23].

Table 1. Size structure of *Corbicula fluminea.*

Parameters	Minimum	Maximum	Mean
SL (mm)	10.10	49.50	32.04
SW (mm)	21.60	50.00	37.10
SD (mm)	5.10	36.00	17.89
LW (g)	2.80	55.13	22.68
WSW (g)	0.98	19.30	7.94
DSW (g)	0.64	12.54	5.16
STW (g)	0.30	9.80	3.81
DSTW (g)	0.12	1.97	1.03
ISCC (cm^3)	2.16	42.59	17.52

As to the size structure of *P. exilis,* the minimum shell length is 12.30 mm, maximum shell length is 42 mm and mean shell length is 30. 55 mm. Minimum live weight is 20.90 g, maximum body weight is 40.60 g and mean body weight is 26.16 g. Mean values recorded for wet shell weight and dry shell weight on the hand were 6.28 and 4.75 g. With regard to soft tissue weight and dry soft tissue weight, mean was recorded at 12.50 and 0.96, respectively. Meanwhile, the mean internal shell cavity capacity of the bivalve is 4.73, lowest among the species studied which could be attributed to its shell depth. The computed length of infinity for this bivalve in Indonesia was in between 94.10 to 100.60 mm [24]. In comparison to the values obtained for the shell length recorded in this study, the result may suggest that the *P. exilis* in the locality is still in the growing process.

Table 2. Size structure of *Pilsbryoconcha exilis.*

Parameters	Minimum	Maximum	Mean
SL (mm)	12.30	42.00	30.55
SW (mm)	42.30	93.00	68.72
SD (mm)	4.16	15.31	10.44
LW (g)	20.90	40.60	26.16
WSW (g)	5.02	9.74	6.28
DSW (g)	3.95	6.66	4.75
STW (g)	10.39	17.52	12.50
DSTW (g)	0.15	2.81	0.96
ISCC (cm^3)	0.75	13.89	4.73

Shell length of *C. plicata* collected from the study site ranges from 34.0 to 106.0 mm while shell width ranges from 20.0 to 180.0 mm. A study in Lake Oro, Agusan del Sur, Philippines revealed a mean shell length of 134.0 mm [25]. Meanwhile, shell lengths of *C. plicata* found in the Russian Far East were in the range of 100-250 mm [26]. Live weights of *C. plicata* are ranging from 46.80 to 756.20 g. As reported, mean live weight of the species in the Lake Oro is 136.33. As to wet shell weight and dry shell weight, the species recorded a mean of 129.69 g and 775.42 g, respectively. In terms of soft tissue weight, the observed values are in between 15.30 to 217.10 g with a mean of 84.43 g. For the dry soft tissue weight, a mean of 25.33 g was recorded. The mean of its internal shell cavity capacity is 153.12, of which, highest among the species assessed.

Table 3. Size structure of *Cristaria plicata.*

Parameters	Minimum	Maximum	Mean
SL (mm)	34.00	106.00	68.59
SW (mm)	20.00	180.00	114.87
SD (mm)	11.00	71.50	42.53
LW (g)	46.80	756.20	228.54
WSW (g)	25.74	415.91	125.69
DSW (g)	15.44	249.55	75.42
STW (g)	15.20	217.10	84.43
DSTW (g)	4.56	65.13	25.33
ISCC (cm^3)	31.36	506.65	153.12

Although, the size structure of the three edible bivalves can't be directly attributed to such factors at present, the lowest values obtained in the sizes may correspond to their size at first capture.

Meat Yield

The meat yield of bivalves is indicated in Table 4. The meat yields of the species are as follows: 32.48% in *C. fluminea*, 28.71% in *P. exilis* and 36.94% in *C. plicata.* Results revealed that meat yield of the collected species are low compared to the meat yield recorded to other bivalve species which peaked at 59.67% [27].

Meat yield of bivalves is related to reproduction and environmental conditions [28-32]. Given that the species are collected with no size discrimination, there is a possibility that prior to harvesting most of the samples are still in immature stage or have already undergone spawning. Low meat yield during spawning period was reported [33]. In addition, the meat yield has been considered as most sensitive to changes during reproductive development [34].

Table 4. Meat yield from the freshwater bivalves.

Bivalve Species	Meat Yield (%)
C. fluminea	32.48%
P. exilis	28.71%
C. plicata	36.94%

The main component of bivalve's diet includes phytoplankton, organic detritus, dissolved organic matter and zooplankton [35-37]. Food supply has consistently been shown to be the most important factor in determining bivalve growth in both controlled and wild environment. In the wild, growth has been shown to be correlated with phytoplankton abundance [38-39]. However, the values obtained for meat yield in this study could not be linked directly to these factors due to the absence of reproductive and food analyses.

Condition Index

Condition index has been used as a scientific method to assess the eco-physiological condition of commercially important bivalve and other molluscan species [40-41]. Results of the analysis of condition index of freshwater bivalves are presented (Table 5). Condition index of *C. fluminea* ranges from 6.24 to 47.39 with a mean of 22.50 while Ci *P. exilis* ranged from 3.83 to 43.30 averaging 19.16. On the other hand, Ci of *C. plicata* ranged from 11.96 to 77.29 with a mean of 35.63.

Table 5. Condition index of the freshwater bivalves.

Bivalve Species	Condition index (Ci-shell)		
	Minimum	Maximum	Mean
C. fluminea	6.24	47.39	22.50
P. exilis	3.83	43.30	19.16
C. plicata	11.96	77.29	35.63

The result on the Ci-shell analysis of *C. fluminea* is relatively lower than the previous report after subjecting the bivalve in wastewater for 72 days [42]. Low condition index indicates post-spawning season and non-suitability of the resources for harvesting [36]. Meanwhile, there is still lack of research works dealing on the condition index of *P. exilis* and *C. plicata* suggesting that optimum condition index for these species has not been established. Hence, it cannot be stated that the obtained values for the two species are higher or lower due to the absence of such reference value. However, the information generated form these species may serve as reference in the harvesting of bivalves.

Shell Dimension-Weight Relationships

The length-weight relationship is commonly used as an indicator of biological fisheries, changes in individual and population status and growth pattern of organisms [43-46]. Results revealed that relationship of shell dimensions to live weight showed a negative allometric growth for the three species studied, as reflected by low *b* values (i.e., <3). This also indicates that shell length increases faster compared to the weight of the species [46].

The negative allometric growth pattern of the species indicates that they may have undergone through a stressful condition. Previously, it was stated that the b value should remain between 2.5 to 4.0 in order for the mollusc to exhibit isometric growth [47]. The dimensions of the shell are commonly used as an indicator of weight growth. Looking deeper at the details, it can be noted that shell length is the ideal estimator for the weight of *P. exilis* and *C. plicata* while shell depth and shell length can be used as good estimators for *C. fluminea* weight. Bivalve shell growth and shape are influenced by biotic and abiotic factors [48-49]. Some of these factors include the condition of the environment and the availability and quality of food.

Table 6. Relationship of Shell Dimensions and Live Weight.

Bivalve Species	Variables	r	r^2	a	b	t	Growth Pattern
C. fluminea	SL/LW	0.947	0.897	-4.543	2.176	b≠3	(-)allometric
	SW/LW	0.814	0.663	-7317	2.841	b≠3	(-)allometric
	SD/LW	0.948	0.899	-1.733	1.652	b≠3	(-)allometric
P. exilis	SL/LW	0.939	0.883	-5.924	2.212	b≠3	(-)allometric
	SW/LW	0.909	0.826	-4.389	1.465	b≠3	(-)allometric
	SD/LW	0.667	0.445	2.648	0.265	b≠3	(-)allometric
C. plicata	SL/LW	0.527	0.278	0.286	1.191	b≠3	(-)allometric
	SW/LW	0.318	0.101	2.499	0.5832	b≠3	(-)allometric
	SD/LW	0.477	0.228	2.540	0.743	b≠3	(-)allometric

CONCLUSION AND RECOMMENDATION

The study is the first report on edible bivalve populations in the impoundments of Pampanga State Agricultural University, Magalang, Pampanga. Based from the result of the study, the meat yield is low during the period of the study implying its non-suitability for harvest. The bivalves also exhibited low condition index (for *C. fluminea* only due to the absence of reference values for *P. exilis* and *C. plicata*) and growing following a negative allometric pattern (all species). Shell depth and shell length were found as ideal estimator for the increase in the weight of *C. fluminea* while only shell length is considered as good estimator for the weight of *P. exilis* and *C. plicata*. The information provided by the present study can be used as reference for further research works that will determine the seasonal changes and level of exploitation in the area and the potential of the three species for aquaculture or artificial propagation. Thus, monthly assessment of its biological condition such as growth pattern, body condition, reproductive status and recruitment must be taken into consideration. Also, studies on environmental factors that influence the biological condition of the resources must be carried out.

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