Relationship between Fecundities and Size (Length and Weight) of Freshwater Mussels *Lamellidens lamellatus* (Lea, 1838) From Ayeyawady River and Taungthaman In (Lake)

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Abstract

The study conducted on the relationship between the fecundity and size (length and weight) on 140 specimens of *Lamellidens lamellatus* from oxbow of Ayeyawady river (Paypin village) and Taungthaman In (Lake) revealed that the relationship between shell length, live weight, wet weight and fecundities were significant ($p<0.05$). The result from the Ayeyarwady specimens showed that the mean fecundity was 356490 for the mean size (6.694 cm) and slope 'b' (1.2274) while those of Taungthaman In, revealed the mean fecundity of 257294 for the mean size (5.831cm) and slope 'b' (1.9432). Since the slope was b<3, it is envisaged that the gravid mussels (with glochidium or egg) increased production of fecundity up to their maximum size, beyond the reproduction decreasing.

Key words: Freshwater mussels, Fecundity, *Lamellidens lamellatus*

Introduction

Freshwater mussels of the family Unionoida have become increasingly important to conservationists in recent years because a large number of (mussel species) are threatened and endangered. Unionoids are relatively diverse in North America with 297 species. Yet, over half of these species are of special concern, threatened, endangered, or already extinct. The decline of freshwater mussels in the U.S.A is a national issue stemming from factors related to habitat loss and degradation of river and lake ecosystems. Management and restoration of native mussels will require a thorough understanding of species life history and population biology (National Native Mussel Conservation Committee, 1998).

Freshwater mussel is an important ecological component of most aquatic systems. Mussels are extremely important to freshwater communities. They are food for many mammals and birds, and they help maintain good water quality by filtering nutrients, contaminants, and sediments from the water. The decline of mussel abundance or the disappearance of mussel from a river or lake may be an indication of substantially deteriorating water and environmental qualities. However, one of the main problems in tropical regions is the lack of information on the basic biology of bivalve species (Richmond, 1999).

Reproduction in unionid molluscs is a complex process. The freshwater mussel has a unique life cycle, to include a short parasitic stage attached to a fish. Unionids have internal fertilization and females retain (i.e. brood) their embryos and larvae (i.e. glochidia) within gill chambers called marsupial. The ripe eggs in a female pass from the ovaries to the suprabranchial

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chambers where they are fertilized by sperm discharged to the water column from a male. The eggs become attached by mucus within the water tubes of her gills which enlarge as brood chambers (marsupials). Egg formation and fertilization are critical steps, to achieve complete fertilization (Matteson, 1948).

A high mussel density may increase the chance of fertilization and result in the production of high numbers of larvae. Mussel population size should also be positively related to larval production. The freshwater mussel gonads may have a few or many eggs and of importance in estimating the number of individuals at the start of new generation and population studies. It is usually found to measure with size and age of the freshwater mussels in order to compare fecundities of mussels of different size or from different places. The parasitic habit of unionids is associated with very high fecundity, (Barnhart, 2005).

Fecundity, defined as the number of eggs or offspring produced by a female is one of the most important factors in the management of unionids. It is also an important aspect of biology to study when comparing different species or different populations of same species, as if one is more fecund than the other, it may be more successful for reproduction. Fecundity and productivity are important components of a species' life history. Many freshwater mussel conservation measures are based on knowledge of their reproductive cycle and biology.

Thus, the objective of the present work is:

- to determine the relationship between shell length, live weight, wet weight and fecundities of *Lamellidens lamellatus* from Ayeyawady river and Tanugthaman In (Lake)

Materials and Methods

Study Area

Freshwater mussels are collected from oxbow of Ayeyawady river (Paypin village) and Taungthaman In (Lake) (Fig. 1).

A 

B. T 

Fig. 1 Location of collection sites (Source: Google earth, Accessed 18 June 2016)

Study Period

The study was conducted from June, 2016 to May, 2017.

Collection of Specimens

The specimens were easily picked up by bare hand in shallow water; a long–handled rake was used in moderate and 150 cm depth or more.

Lamellidens lamellatus samples with shell size range from 3.0 cm to 9.0 cm were collected monthly.

Maintenance of the Specimens

Captured specimens were kept in an icebox with ice pellets and then transferred to the laboratory and cultured in glass aquaria of (90×45×45 cm) with sand floor.

Identification

Identification was based on Preston (1915), Nedeau and Victoria (2005) and Harrold and Guralnick (2006).

Parameters Taken

Monthly samples of 10 female mussels from each study site were used to record the parameters. Anterior–posterior axis as shell length was measured. Measurements were made by Vernier Clippers with an accuracy of 0.05mm.

Live weight was taken after drying the shell with tissue paper. Dissection was made by driving a wooden wedge to cleave the shell apart. The soft parts removed from the shells were weighed for soft wet tissue weight. These weights were taken to the nearest 0.001g by using Adventurer (AR 2140) electronic balance.

Laboratory Procedure

Microscopic examination of the condition of the gonad was assessed according to Kayombo (1986), via coloration examination. The colour of the products of ripe gonad was used to determine the sex. The female's ripe gonad product is light orange in color whereas that of male is white. The shells of females are more inflated than males to provide the space for brooding.

Gravid females were pried open slightly and held open by a small piece of cork placed between the valves. A water–filled syringe with a hypodermic needle was inserted into one of the marsupial gill chambers and glochidia to be liberated from the gill. Glochidia were collected in a petridish. Then eggs were kept in a calibrated burette with water. The eggs were shaken so as to be distributed evenly inside the burette.

The syringe was used to take a known amount of water from the burette and kept on petridish. The petridish was placed under microscope and eggs were counted. The proportion of water taken from known amount of water inside burette was used as a multiplication factor to obtain number of eggs per female.

Data Analysis

The data for shell length, live weight, wet weight to fecundities were subjected to correlation analysis determined according to Harlioglu *et al.* (2004). Fecundity increases at a greater rate than the shell length, live weight and wet weight in *L. lamellatus*, slopes were investigated by applying regression analysis of log transformed variables in the form

$$\log y = \log a + b \log x$$

Where X is shell length, live weight and wet weight and Y is fecundity, 'a' is the intercept and 'b' is the slope of parameter. The value of the constant b will be >3.0 when the fecundity increases at a greater rate than the shell length, live weight, wet weight, b will be < 3.0 when the fecundity decrease at a less rate than the shell length, live weight, wet weight and this relation is isometric when the constant b is equal to 3.0.

Results

A total of 596 individuals, the freshwater mussels, were collected in oxbow of Ayeyawady river (Paypin village) and 365 individuals in Taungthaman In (Lake) from June, 2016 to May, 2017 (Table 1 & Plate 1).

In the study period, monthly measured shell length, live weight, wet weight and fecundity of *Lamellidens lamellatus* from Ayeyawady and mean fecundities of different size of *L. lamellatus* were given in (Table 2). And also monthly measured shell length, live weight, wet weight and fecundity of *L. lamellatus* from Taungthaman In (Lake) and mean fecundities of different size of *L. lamellatus* were shown in (Table 3).

The maximum fecundity of *L. lamellatus* from oxbow of Ayeyawady river, 446750 ± 579 eggs, was observed in the size range of 8.005 – 8.885 cm shell length whereas minimum fecundity was 126237 ± 502 eggs in the size range of 3.795– 3.925 cm shell length (Plate 3). The relationship between the shell length and fecundity were significantly correlated r^2 = 0.7911 ($p < 0.05$). The slope (b) value was 1.2274 (log fecundity = 4.5313 + 1.2274 log length) (Fig. 2). The relationship between the live weight of and fecundity were significantly correlated r^2 = 0.6806 ($p < 0.05$). The slope (b) value was 0.5354 (log fecundity = 4.7534 + 0.5354 log live weight) (Fig. 3). The relationship between the wet weight and fecundity were significantly correlated r^2 = 0.7186 ($p < 0.05$). The slope (b) value was 0.5065 (log fecundity = 4.9601 + 0.5065 log wet weight) (Fig. 4).

The maximum fecundity of *L.lamellatus* from Taungthaman In, 431394±809 eggs, was observed in the size range of 8.015–8.255 cm shell length. The minimum fecundity, 93438 ± 484 eggs was noted in the size range of 3.315–3.995 cm shell length (Plate 3). The relationship between the shell length and fecundity were significantly correlated r^2 = 0.7802 ($p < 0.05$). The slope (b) value was 1.9432 (log fecundity = 3.9007 + 1.9432 log length) (Fig. 5). The relationship between the live weight of and fecundity were significantly correlated r^2 = 0.6798 ($p < 0.05$). The slope (b) value was 0.8186 (log fecundity = 4.2931+0.8186 log live weight) (Fig. 6). The relationship between the wet weight and fecundity were significantly correlated r^2 = 0.7485 ($p < 0.05$). The slope (b) value was 0.7904 (log fecundity = 4.5299 + 0.7904 log wet weight) (Fig. 7).

The slope (b) values relating to shell length and fecundity were 1.2274 and 1.9432 in oxbow of Ayeyawady river and Taungthaman In (Lake) respectively. It was less than b = 3. The slope (b) values relating to live weight and fecundity were 0.5354 and 0.8186; wet weight to fecundity were 0.5065 and 0.7904 in oxbow of Ayeyawady river and Taungthaman In (Lake) respectively. It was also significantly less than b = 3 (Table 4 and 5).

Table 1 Freshwater mussels *L.lamellatus* collected in oxbow of Ayeyawady river and Taungthaman In (Lake) from June, 2016 to May, 2017

Collected site	Month												
	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Total
Ayeyawady	57	62	44	38	45	55	67	59	62	33	35	39	596
Taungthaman	34	43	23	29	26	36	38	41	38	21	19	17	365
Total	91	105	67	67	71	91	105	100	100	54	54	56	961

Table 2 Mean fecundity of different sizes of *L. lamellatus* from oxbow of Ayeyawady, June, 2016 to May, 2017 (n=70)

Size ranges (shell length, cm)	Number	Mean shell length (cm)	Mean fecundity
3.795 – 3.925	2 (2.85)	3.860 ± 0.065	126237 ± 502
4.215 – 4.995	5 (7.14)	4.485 ± 0.283	215303 ± 381
5.125 – 5.965	14 (20.0)	5.463 ± 0.291	286266 ± 255
6.105 – 6.905	16 (22.85)	6.640 ± 0.263	347556 ± 353
7.055 – 7.905	18 (25.71)	7.325 ± 0.232	408637 ± 366
8.005 – 8.885	15 (21.42)	8.581 ± 0.239	446750 ± 579
Total(mean)	70	6.694 ± 1.331	356490 ± 893

Table 3 Mean fecundity of different sizes of *L. lamellatus* from Taungthaman In (Lake), June, 2016 to May, 2017 (n=70)

Size ranges (shell length, cm)	Number	Mean shell length (cm)	Mean fecundity
3.315 – 3.995	9 (12.85)	3.746 ± 0.192	93438 ± 484
4.115 – 4.915	14 (20.0)	4.415 ± 0.291	166938 ± 219
5.115 – 5.825	12 (17.14)	5.410 ± 0.249	219574 ± 437
6.055 – 6.885	15 (21.42)	6.423 ± 0.253	296670 ± 593
7.015 – 7.855	17 (24.28)	7.460 ± 0.299	379611 ± 863
8.015 – 8.255	3 (4.28)	8.175 ± 0.113	431394 ± 809
Total (mean)	70	5.831 ± 1.419	277294 ± 117

Parenthesis = (percent %)

Table 4 Result of relationship for shell length (log), live weight (log) and wet weight (log) to fecundity (log) of *L. lamellatus* from Ayeyawady, during study period (n=70)

Relationship	a	b	r^2
Shell length (log) and Fecundity (log)	4.5313	1.2274	0.7911
Live weight (log) and Fecundity (log)	4.7534	0.5354	0.6806
Wet weight (log) and Fecundity (log)	4.9601	0.5065	0.7186

Table 5 Result of relationship for shell length (log), live weight (log) and wet weight (log) to fecundity (log) of *L. lamellatus* from Taugthaman In (lake), during study period (n=70)

Relationship	a	b	r^2
Shell length (log) and Fecundity (log)	3.9007	1.9432	0.7802
Live weight (log) and Fecundity (log)	4.2913	0.8186	0.6798
Wet weight (log) and Fecundity (log)	4.5299	0.7904	0.7485

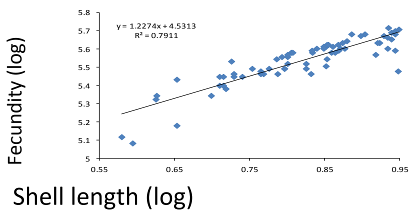


Fig. 2 Relationship between shell length (log) and fecundity (log) of *L. lamellatus* from Ayeyawady (n = 70)

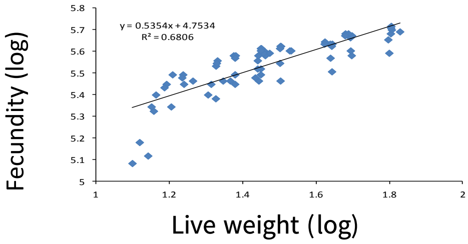


Fig. 3 Relationship between live weight (log) and fecundity (log) of *L. lamellatus* from Ayeyawady (n = 70)

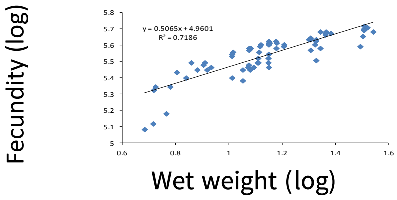


Fig. 4 Relationship between wet weight (log) and fecundity (log) of *L. lamellatus* from Ayeyawady (n = 70)

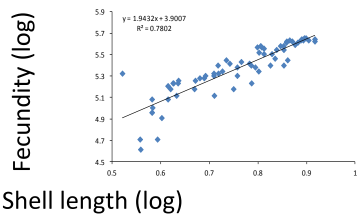


Fig. 5 Relationship between shell length (log) and fecundity (log) of *L. lamellatus* from Taungthaman In (Lake) (n = 70)

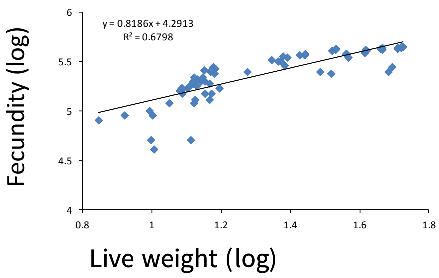
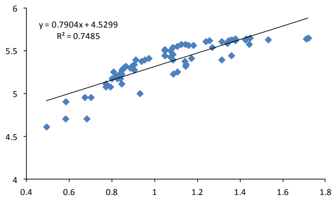


Fig. 6 Relationship between live weight (log) and fecundity (log) of *L. lamellatus* from Taungthaman In (Lake) (n = 70)

Fecundity (log)



Wet weight (log)

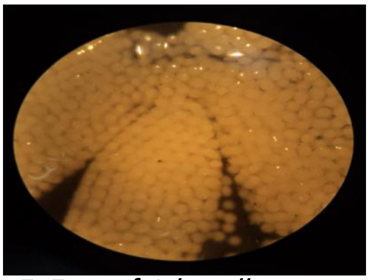
Fig. 7 Relationship between wet weight (log) and fecundity (log) of *L. lamellatus* from Taungthaman In (Lake) (n = 70)

A. Collected specimens

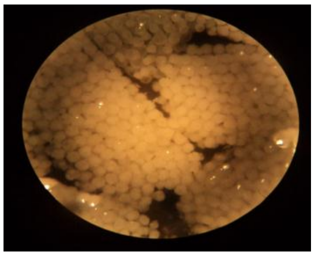
B. Collected specimens (From Taungthaman In)

C. Gravid female of *L. lamellatus* (From Ayeyawady)

D. Gravid female of *L. lamellatus* (From Taungthaman In)



E. Eggs of *L.lamellatus* (From Ayeyawady)



F. Eggs of *L.lamellatus* (From Taungthaman In)

Plate 1 Gravid female and eggs of *L.lamellatus*

Discussion

In this study, the mean fecundity of *Lamellidens lamellatus* was found with 356490 eggs in oxbow of Ayeyawady and 277294 eggs in Taungthaman In. *L. lamellatus* require a fish host in order to complete their life cycle.

Mzighani (2005) reported that the large number of eggs, about 6 millions eggs per female, produced by *Anadara antiquata* is important because external fertilization results in losses due to predation, pollution and other environmental factors. Heard (1975) recorded on European freshwater mussel species between 100,000 and 300,000 glochidia in Unio spp. and

16,000,000 glochidia in *Margaritifera margaritifera*. Johns and Hickman (1985) reported on snapper predation of spat on the mussel, *Perna analiculus* seeded on ropes. Young mussels are also predated by the crab, *Scylla serrata.*

The maximum fecundity was found with the size range 8.005–8.885 cm and 8.015–8.255 cm in oxbow of Ayeyawady river and Taungthaman In respectively. The minimum fecundity was found with the size in the range 3.795– 3.925 cm and 3.315–3.995 cm in oxbow of Ayeyawady river and Taungthaman In respectively.

Downing *et al.* (1993) reported that in the freshwater mussels *Elliptio complanata,* both the probability of producing eggs and the number of ova produced increased with body size up to a shell length of 8 cm beyond which they fall rapidly.

Bascinar and Duzgunes (2009) reported that the *Anodonta cygnea* of the gravid freshwater mussels (with glochidium) were found in 75–125 mm length range n=733 (88%). The smallest gravid mussels were observed in the 55–65 mm length group and the maximum rate was reached (30%) in the 95–105 mm length group. The number of glochidia produced depends on both the size of glochidia and the size of the female mussel. They range from a few thousand to several millions. It shows differences depending on species.

David (1999) states that fecundity in Unionids ranges from several thousand eggs in the smaller species to more than 3 million in some of the larger ones. Fecundity, as shown above, ranged from 10,000 eggs for an individual of less than 30 mm to almost 26,000 eggs for an individual of slightly over 45 mm. As it could be expected a good correlation (r = 0.850) existed between length of mussel and number of eggs contained by the individual, with larger mussels having two to three times more eggs than the smaller ones.

In the present study, *L. lamellatus* from both study sites showed that the mean fecundity of the specimens increased linearly with the gain in mean shell length. The results of the correlation analysis conducted between the shell length and fecundity in both the study sites, Ayeyarwady (r^2= 0.7911) and Thaungthaman In (r^2= 0.7802). The relationship between fecundity and live weight, wet weight were significantly correlated r^2=0.6806 and r^2=0.7186 in oxbow of Ayeyarwady river and r^2=0.6798 and r^2=0.7485 in Thaungthaman indicating significant correlation that enhance the truth in the statement above.

In fisheries biology, the relationship between log egg number and log size has been commonly used for description data, in order to stabilize the variance in fecundity. This relationship employs the power function or allometric model based on the equation $\log y = \log (a) + b \log x$. The relationship between fecundity and size (length) differs by a factor (3). Consequently, if the slope is $b > 3$ or $b < 3$, fecundity increases or decreases with body size and implies the absence of a simple volumetric relationship (Somers, 1991).

In present study, the relationship between the shell length, live weight, wet weight and fecundities *L. lamellatus* in both study sites were significantly correlated but based on allometric model ($\log y = \log a + b \log x$) the slope "b" was smaller than 3.

According to result, the gravid mussels (with glochidium or egg) increased their production of egg up to their maximum size, beyond which reproduction decreased.

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