Shell Band Pattern of Golden Apple Snail (*Pomacea Cancaliculata*, Lamarck) in Selected Aquatic Habitats

Gloria L. Galan, Heidi C. Porquis, and Mae Ann R. Bulasa

***Abstract*—Environmental factors affecting band patterns in the shell of *Pomacea canaliculata*, (Lamarck 1822) were assessed from shell samples taken in selected sites in Central Mindanao University campus, and vicinities in Bukidnon province, Philippines. Shell samples with sizes of 2 cm and above were used. The conchological characteristics measured were number of whorls, number of bands, width of each band, width of the shell aperture and shell length. Live weight of each individual snail was taken. The depth, temperature, pH, dissolved oxygen (DO) and salinity of water were also measured. Pearson correlation analysis shows that only variation in water depth had significant influence on the variation in the number of bands (r=-.973, P=.01) and the average band width (r=.892, P=.05).**

***Index Terms*—Pomacea canaliculata, conchology, water depth.**

I. Introduction

Interest in the golden apple snail (*Pomacea canaliculata* Lamarck, 1828) as a food resource and gourmet export item was noted as the basis of its introduction into the Philippines [1]. That this initiative did not succeed is a common knowledge. Facts of the invasive character of the species became evident after it was seen to cause serious damage to the rice fields following its probable escape or release into the wild [2]. The issue however is crossing national borders such that measures are taken to address the problem [3], [4].

Conchological characters in molluscs are primarily useful in identifying taxonomic groups as well as clarifying issues on populations within a given taxon [5]-[7]. However, there are findings that could show that these characters could provide visual links between environmental factors and development thus increasing understanding of a species. For instance, a study on the Roman snail (*Helixpomatia*) shows that heavy metal accumulation in the hepatopancreas could affect shell height, relative shell height and whorl number [8]. Other indications of environmental influence on conchological characters are shown in shell shape spectrum in *Margaritiferamargaritifera*(L.) with river water pH and with current for *Semisulcospirareinniana* [9], [10]. In *P. canaliculata*, banding pattern is a conchological character with ontogenetic and ecophenotypic components; attributes of the character being color, intensity, number and width of bands [11]. This study was also directed towards the same issue but in the local *in situ* setting. The relationship between selected environmental factors and some measurable aspects of shell band pattern in *P. canaliculata* were addressed. The empirical observations presented here might be useful as reference for future studies.

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II. Methodology

The entry protocol was followed by an ocular inspection of the study sites: 1) Lake Napalit, 2) Lake Apo, 3) Pulangi Lake, 4) CMU PhilRice, 5) CMU fishpond, and 6) CMU Ricefield. Of these impoundments (Fig. 1-Fig. 6), only Lakes Napalit and Apo are natural formations. Two small creeks join to form the Lake Napalit tributary. The lake in turn drains into the Muleta River. Corn and sugar farmlands surround this lake as well as some trees and few small houses. For Lake Apo, the surroundings are a few households, a local tourism spot and both residual forest and planted trees. Small springs partly feed the Lake and its single outlet drains into the Pulangi River, also called the Rio Grande de Mindanao. The rest of the sampling sites are manmade impoundments. Pulangi Lake is a backflow water body resulting from the construction of the NAPOCOR hydroelectric power plant. All these are a few kilometers from the campus of Central Mindanao University in Bukidnon, Philippines. The three others, CMU PhilRice, CMU fishpond and CMU Ricefield, are within the 3,081 hectare university campus.

Water depth was measured using a meter stick; temperature with a laboratory thermometer, and pH with a pH paper and a pH paper standard chart for comparing color. A handheld Refractometer (Atago S/Mill-E) was used in determining salinity and the Winkler Method was followed for getting dissolved oxygen (DO).Data taken were average of three trials. On the other hand, snail samples were collected by hand picking. An arbitrary lower limit of size for samples collected was about 2 cm. to exclude juveniles. Data collection in all sites including snail sampling was only within a distance of one (1) meter from the shoreline.

Collections were placed in properly labeled plastic bags. Subsequent processing of the specimens included boiling for easy meat extraction, and cleaning of the shell. Protective gloves were used. Morphometric data (Fig. 7-Fig. 10) to characterize shell band pattern included shell length, width of the aperture, band width per shell, number of bands, and number of whorls. Measurements were to the nearest millimeter (mm). All bands in each collected shell were

measured. Individual weights of live snails were also recorded. Two sampling visits were made per site for the period of June 2010 to February 2011. Twenty (20) samples were randomly collected from each station per visit.

Fig. 1. Lake Napalit.

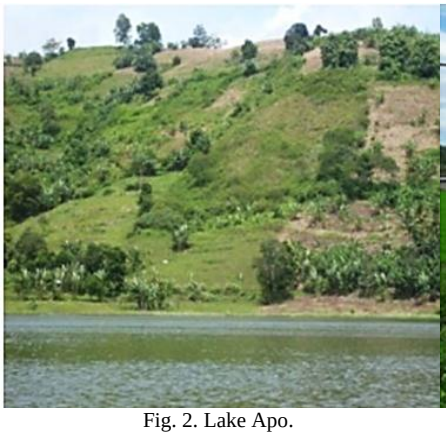

Fig. 2. Lake Apo.

Fig. 3. CMU Rice field.

Fig. 4. CMU PhilRice.

Fig. 5. CMU Fishpond.

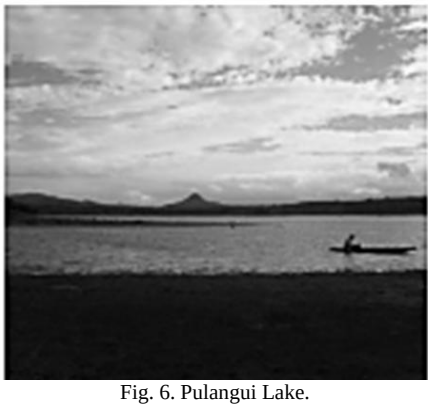

Fig. 6. Pulangui Lake.

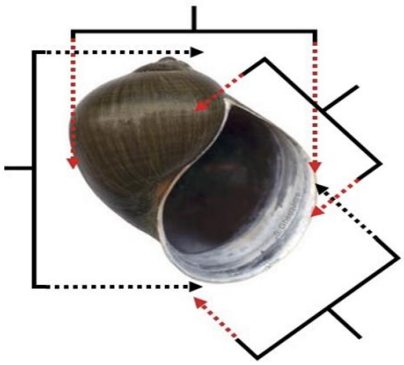

Fig. 7. Measuring aperture width.

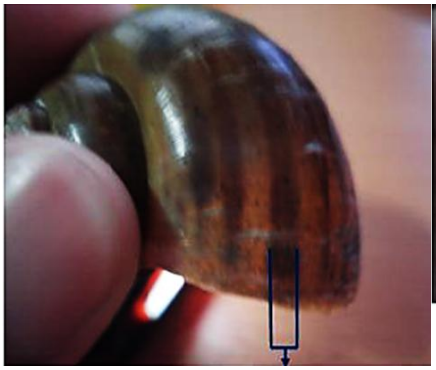

Fig. 8. Measuring band width.

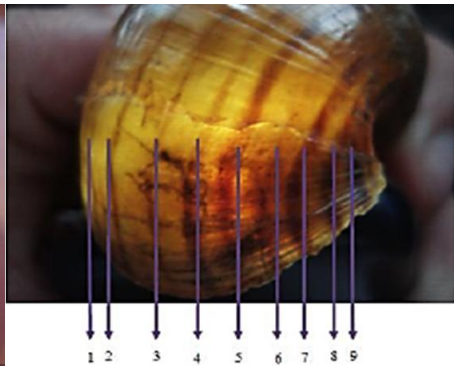

Fig. 9. Counting number of bands.

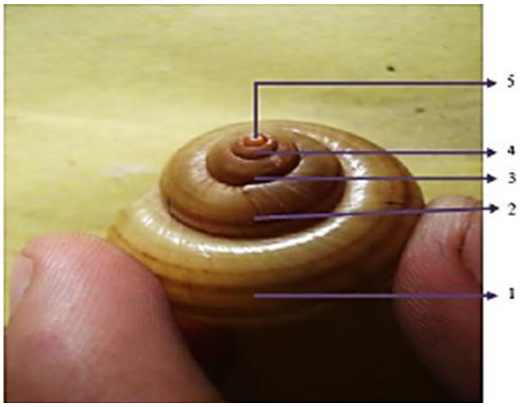

Fig. 10. Counting number of whorls.

III. Results

Mean data for the weight, shell measurements and physico-chemical parameters are given in Table I. Highest mean for weight and length were observed for the Pulangi collections. For aperture size and band width, the mean values for Lake Apo collections were higher than those of the other sites. But for the means in the number of bands and whorls, highest figures were from CMU fishpond and CMU rice fields samples, respectively. One remarkable feature observed was the presence of some discontinuous bands in some shells.

Pearson correlation analysis (Table II and Fig. 11) on the conchological features and physico-chemical parameters indicates that the variation in the number of bands and the average band width are significantly correlated only with depth. For the number of bands, a negative (r=-.973, P=.01) correlation appears with depth while for the band width, correlation with the said environmental factor is positive (r=.892, P =.05).

TABLE I: MEAN DATA ON SHELL MORPHOMETRICS OF *P. CANALICULATA* LAMARCK AND PHYSICO-CHEMICAL PARAMETERS IN THE SIX SAMPLING AREAS AT TWO SAMPLING VISITS PER SITE FOR THE PERIOD OF JUNE, 2010 TO FEBRUARY 2011

MEAN MORPHOMETRIC DATA ON THE SIX SAMPLING AREAS							PHYSICO-CHEMICAL PARAMETERS (MEAN VALUES)				
	WEIGHT	LENGTH	SIZE OF APERTURE	NO. OF BANDS	NO. OF WHORLS	BAND WIDTH	DEPTH	pH	SALINITY	TEMPERATURE	DO
	(g)	(mm)	(mm)			(mm)	(m)		(ppt)	(^{0} C)	(mg/L)
NAPALIT LAKE	0.98	26.33	21.8	10.97	2.92	0.98	4.13	7.8	0.6	26.8	7.8
PULANGUI LAKE	3.51	37.48	22.62	10.62	2.98	0.99	3.7	7.5	0.25	30.5	7.95
LAKE APO	1.5	33.76	24.94	8.58	3.05	1.36	7.6	7	1.002	29.4	7.4
CMU FISHPOND	1.72	36.22	20.27	11.81	4.02	0.89	2.81	7	1	27.7	9.9
CMU PHILRICE	1.472	31.17	17.07	11.2	4.025	0.95	3	7	1	28	8.6
CMU RICEFIELD	1.73	36.09	20.22	11.26	4.04	0.74	3.5	7	1	27.3	7.4

TABLE II: CORRELATION BETWEEN CONCHOLOGICAL CHARACTERS (APERTURE, BANDS AND WHORLS) AND PHYSICO-CHEMICAL PARAMETERS

	DEPTH	pH	SALINITY	TEMPERATURE	DO
APERTURE Sig.(2-tailed) 	.804 .054 6	.271 .603 6	-.322 .534 6	.491 .322 6	-.478 .338 6
NO. OF BANDS Sig.(2-tailed) 	**-.973**** .001 6	.064 .904 6	-.005 .993 6	-.544 .265 6	.605 .204 6
NO. OF WHORLS Sig.(2-tailed) 	-.581 .227 6	-.731 .099 6	.691 .128 6	-.446 .375 6	.501 .311 6
BAND WIDTH Sig.(2-tailed) 	**.892*** .017 6	-.020 .970 6	.013 .980 6	.514 .297 6	-.280 .591 6

- **Significant at 0.01 (level) - ****
- **Significant at 0.05 (level) - ***

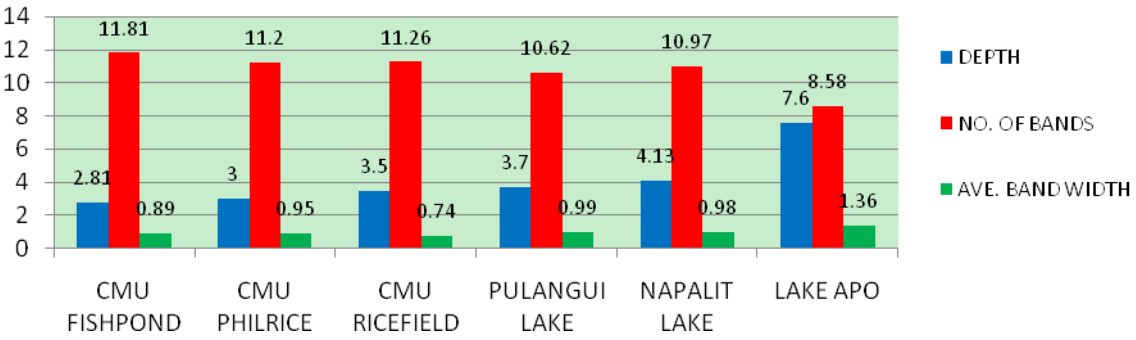

Fig. 11. Mean values for water depth and number of bands and average band width.

IV. DISCUSSION

The data obtained in this study appear to link water depth to shell band number and band width. As indicated in the Pearson's correlation analysis, increase in water depth has 97% influence on the decrease in the average band number. At the same time, increase in the said factor has 89% influence on the increase in band width. While data in this study may add to existing information on relationships between environment and the development of conchological characters that are reported in literature, basic questions on the mechanisms involved remain unanswered. The study showing that polyenespresent in the colored parts of the shell and even more concentrated in parts with higher colour saturation is a useful lead on the existence of shell bands in general [12]. The same report however recognizes also the role of proteins and carbohydrates shown by earlier investigators in forming the outer shell matrix. Moreover, the neurosecretory model of shell growth and pattern formation and the recognition that shell growth and pig mentation involves neurosecretory activity of the mantle could help elucidate not only the regularity of shell design but also its alteration when there is environmental disturbance [13]. This idea could help explain why some shell bands in some individuals were discontinuous.

In the light of this information it is probable that the influence of the variation in water depth on shell band no. and average band width may have operated by way of this neurosecretory pathways in the golden apple snail. The possibility however that the other environmental factors may also exert influence cannot be ruled out. This is because neurosecretory activities are known to operate along

threshold levels. For *P. canaliculata*, it is probable that variations in the other factors have not yet attained the required threshold for the species. However, this could be resolved in further investigations.

V. Conclusion

Among the relationships studied only that between water depth to average band width and the number of bands was established with the former showing a negative influence onthe variation onnumber of bands and a positive influenceon the average band width in *P. canaliculata.*

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References

[1] Global Invasive Species Database. (2005). *Pomacea canaliculata* (mollusc). [Online]. Available: http://www.issg.org/database/species/ecology.asp?si=135

[2] R. C. Joshi, M. S. Delacruz, E. C. Martin *et al*., "Current status of the golden apple snail in the Ifugao rice Terraces, Philippines," *Journal of Sustainable Agriculture Journal*, vol. 18, no. 2-3, pp. 71-90, 2001.

[3] R. H. Cowie. (2005). Invasive apple snails (Ampullariidae) in Hawaii and Southeast Asia. Center for Conservation Research and Training, University of Hawaii American Malacological Society. [Online]. Available: http://www.malacological.org/meetings/archives/2004/

[4] M. E. Seuffert, L. Saveanu, and P. R. Martin. (2012). Threshold Temperatures and Degree-Day Estimates for Embryonic Development of the Invasive Apple Snail *Pomacea canaliculata* (Caenogastropoda: Ampullariidae) *Malacologia* [Online]. 55(2). pp. 209-217. Available: http://www.biome.org/doi/abs/104002/040.055.0203

[5] K. A. Hayes, R. H. Cowie, S. C. Thiengo, and E. E. Strong, "Comparing apples with apples: clarifying the identities of two highly invasive Neotropical Ampullariidae (Caenogastropoda)," *Zoological Journal of the Linnean Society*, vol. 166, pp. 723-753, 2012.

[6] R. H. Cowie, "Shell pattern polymorphism in a 13-year study of the Land Snail *Thebapisana* (Muller) (Pulmonata: Helicidae)," *Malacologia*, vol. 34, no. 1-2, pp. 87-97, 1992.

[7] M. A. J. Torres, L. R. T. Amarillo, R. Joshi, L. Sebastian, Z. Baoanan, and A. G. Demayo, "Intra- and Inter-Population Variability in the Golden Apple Snail *Pomacea canaliculata*," *Australian Journal of Basic and Applied Sciences*, vol. 5, no. 6, pp. 789-800, 2011.

[8] D. V. Nica, M. Bura, I. Gergen, M. Harmanescu, and B. Despina-Maria, "Bioaccumulative and conchological assessment of heavy metal transfer in a soil-plant-snail food chain," *Chemistry Central Journal*, vol. 6, no. 55, 2012.

[9] S. J. Preston, A. Harrison, M. Lundy, D. Roberts *et al*., "Square pegs in round holes-the implications of shell shape variation on the translocation of adult *Margaritiferamargaritifera* (L.). *Aquatic conservation: Marine and freshwater ecosystems*," *Research and Development Series*, vol. 20, pp. 568-573, Northern Ireland Environment Agency, 2010.

[10] M. Urabe, "Contributions of genetic and environmental factors to shell shape variation in the lotic snail *Semisulcospirareiniana* (Prosobranchia:Pluerocerіdae)," *Journal of Molluscan Studies*, vol. 64, no. 63, pp. 329-343, 1998.

[11] A. L. Estebenet, P. R. Mart ń, and S. Burela, "Conchological variation in *Pomaceacanaliculata* and other South American Ampullariidae (Caenogastropoda, Architaenioglossa)," Universidad Nacional del Sur, Departamento de Biologia, Bioquinica y Farmacia, San Juan 670, 800 Bahia Blanca, Argentina. ISSN 0327-9545, vol. 30, no. 2, 2006.

[12] C. Hedegaard, J.-F. Bardeau, and D. Chateigner, "MolluscanShell Pigments: An *in Situ* resonance Raman study," *Journal of Molluscan Studies*, vol. 72, issue 2, pp. 157-162, August 2005.

[13] A. Boettiger, B. Ermentrout, and G. Oster, February, "The neural origins of shell structure and pattern in aquatic mollusk," *Proceedings of the National Academy of Science of the United States*, 2009.

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