Sains Malaysiana 46(4)(2017): 545–551
http://dx.doi.org/10.17576/jsm-2017-4604-05

Condition Index of *Meretrix lyrata* (Sowerby 1851) and Its Relationship with Water Parameter in Sarawak

(Indeks Keadaan *Meretrix lyrata* (Sowerby 1851) dan Hubungannya dengan Paramater Air di Sarawak)

HADI HAMLI*, MOHD HANAFI IDRIS, AMY HALIMAH RAJAEE, ABU HENA MUSTAFA KAMAL
& MOHAMMAD NESARUL HOQUE

ABSTRACT

Condition Index (CI) was used to estimate the reproductive biology cycle of the hard clam Meretrix lyrata *based on dry body weight and shell weight. High CI value was observed due to the increase in the body weight of the hard clam that corresponding to the maturity stage and early spawning. The CI value of* M. lyrata *from Buntal Village, Kuching, Sarawak showed three highest peaks during the 12-month study on May and October 2013 and March 2014. The lowest CI values were obtained in September and November 2013 and April 2014. Ammonia nitrogen was the only water parameter that significantly correlated to the CI values. The CI application is important to estimate the maturity of hard clam gonad to facilitate conservation activity through the hard clam harvesting out of the gonad maturation and spawning period.*

Keywords: Ammonia; condition Index; gonad maturation; Meretrix lyrata*; Sarawak*

ABSTRAK

Indeks keadaan (CI) digunakan untuk menganggar kitaran biologi pembiakan kekima Meretrix lyrata *berdasarkan berat badan dan berat cengkerang. Nilai CI yang tinggi adalah disebabkan oleh peningkatan berat badan kekima keras yang sepadan terhadap biologi pembiakan pada peringkat matang dan permulaan bertelur. Nilai CI* M. lyrata *dari Kampung Buntal, Kuching, Sarawak mempunyai tiga puncak tertinggi dalam tempoh 12 bulan kajian, iaitu pada Mei dan Oktober 2013 serta Mac 2014. Nilai CI terendah diperhatikan pada September dan November 2013 serta April 2014. Hanya parameter air nitrogen ammonia didapati berkait secara ketara dengan nilai CI. Aplikasi CI adalah penting untuk menganggar kematangan gonad kekima keras bagi memudahkan aktiviti pemeliharaan melalui penuaian kekima keras selain daripada masa kematangan gonad dan bertelur.*

Kata kunci: Ammonia; indeks keadaan; kematangan gonad; Meretrix lyrata*; Sarawak*

INTRODUCTION

The Asian hard clam *Meretrix lyrata* (Sowerby 1851) belongs to the Veneridae family. Species from this family usually inhabit seashores and estuarine areas. Most of the coastal areas near to the estuaries have sediment consisting of sand and mud which are suitable for *Meretrix* species to breed. *Meretrix* species usually burrow itself in the mudflat at the estuaries. The high nutrient content in this habitat is able to support the growth of *Meretrix* clams. *Meretrix* species have developed ciliate structures to prevent their branchiae from becoming clogged by fine particles (Broom 1985; Yoloye 1975). Hamli et al. (2012) reported that Veneridae is distributed across three divisions in Sarawak, and *Meretrix lyrata* is found in the Kuching division. Saline water is the most suitable environment for *Meretrix* species to survive and reproduce. These marine bivalve species contribute to the income of the local communities who depend on it as food source by shell collecting.

The Condition Index (CI) is defined as the mass quantity of the shell to the mass quantity of living tissue in bivalve molluscs (Davenport & Chen 1987). CI increases as the gonad reaches the maturation phase as the amount of meat is greater and CI decreases at spent and rest phases with low amount of meat. The CI is suitable for verifying the gonad maturation phases without the use of chemicals. In Sarawak, CI has been used to study the gonad development of marsh clam *Polymesoda expansa* (Azimah et al. 2013). Other species namely *M. casta* and *M. lusoria* were also studied using CI in India and Japan, respectively (Nakamura et al. 2010; Rao 1988). Gonad development was elucidated in both the studies through Condition Index, Gonad Index and histology. This study on *Meretrix lyrata* forms the baseline to identify the gonad development of the hard clam based on CI as there is no extant study on this species in Sarawak.

MATERIALS AND METHODS

SAMPLE COLLECTION

A total of 60 mature clams of *M. lyrata* (Figure 1) with shell length ranging from 36.0 to 76.0 mm were collected randomly from the intertidal area at the Buntal Village, Kuching division (N 01°42´18.´´ E 110°22´03.6´´) (Figure

2) every month starting from May 2013 until April 2014. Triplicate of water parameters including pH, salinity, temperature, dissolved oxygen, total dissolved solid and conductivity were analysed *in situ* at the study area using multiparameter probe (Model WMS 24 DKK TOA). Water samples from the study area were also triplicately collected during the *M. lyrata* collection and analysed at the laboratory for ammonia nitrogen, nitrite, nitrate, phosphate, total suspended solid and chlorophyll *a*. Monthly data on total rainfall also was recorded based on Malaysian Meteorology Department data for the Buntal Village area. Collected *M. lyrata* samples were brought back to the laboratory and cleaned under running water from fouling organisms and sediment. Total length of *M. lyrata* shell was measured to the nearest ±0.01 mm using Vernier caliper (Mitutoyo) and body weight was taken using electronic balance (Sartorius BS224S) to the nearest ±0.001 g.

ESTIMATION OF GONAD DEVELOPMENT THROUGH CONDITION INDEX

Tissues were removed from the shells of 30 *M. lyrata* individuals and both the tissues and shells were oven dried at 70°C for 48 h before being weighed. The dried shells and tissues were then determined for Condition Index (CI) value based on Marcado-Silva (2005) and Davenport and Chen (1987):

$$\text{CI} = \frac{\text{weight of dry tissue} \times 100}{\text{weight of dry shell}}.$$

The remaining 30 *M. lyrata* individuals were used for Gonad Index (GI) analysis. A small piece of tissue (1 cm^3) was then dissected from the gonad of each individual. This tissue was sliced into 7 to 10 µm using Leica microtome (model RM2255) and stained with hematoxyline and eosin

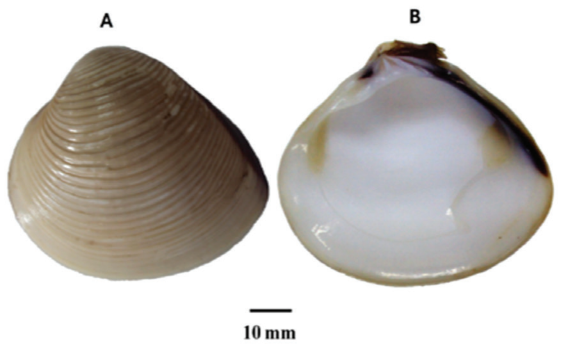

FIGURE 1. *Meretrx lyrata* shell. A: outer shell view; B: inner shell view

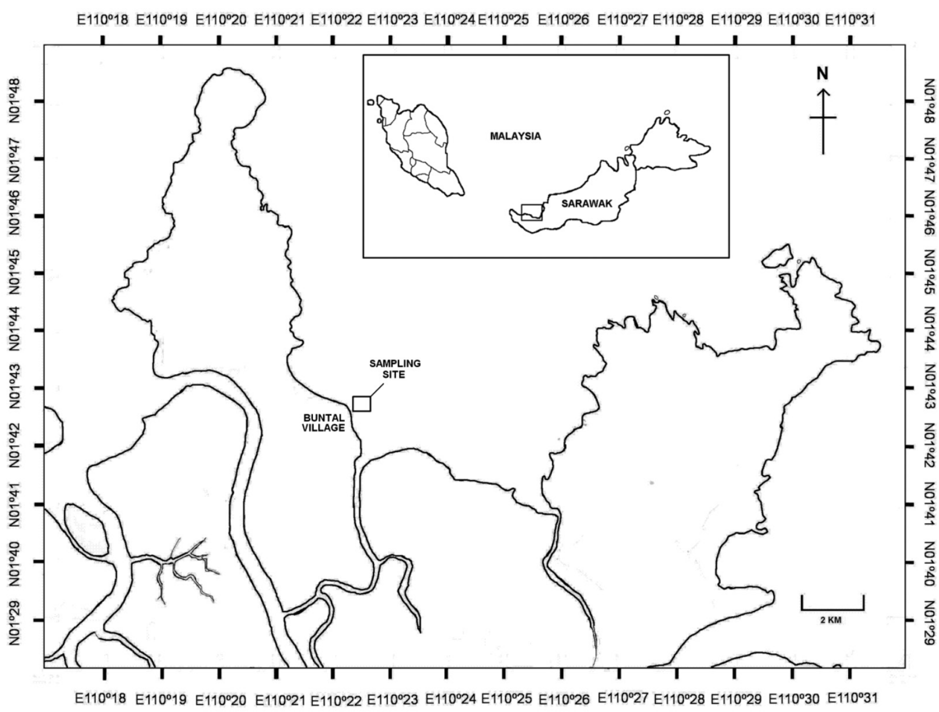

FIGURE 2. Study site for *Meretrix lyrata*

(Humason 1972). The gonad stages for *M. lyrata* were observed under a compound microscope (Leica CME) at 400× magnification and the GI was determined according to Ceballos-Vazquez et al. (2000). Data on CI was analysed for correlation with GI and environmental parameters based on Pearson's correlation (*r*) analysis using Statistical Analysis Software (SAS) version 9.1 (SAS Institute 2004).

RESULTS

The highest CI for *M. lyrata* during the study period was observed in March 2014 with a CI value of 4.26±0.42% (Figure 3) and the lowest CI value (2.47±0.46%) was recorded in April 2014. The CI pattern was high in the first month (May), followed by a decreasing trend until September. The CI pattern then increased significantly ($p<0.05$) in October and decreased remarkably at 2.914±0.49% ($p<0.05$) in November. The increasing trend started gradually until the CI value was notably higher ($p<0.05$) in March and CI pattern noticeably decreased ($p<0.05$) in April as the lowest CI value in the study period.

Monthly study on the GI of *M. lyrata* showed that the total GI was at the highest in June with a GI value of 3 and the lowest was in September with a GI value of 1. A high GI value was recorded for the first two months (May and June) (Figure 4). This pattern then decreased for the next three months with the lowest GI value in September. The GI pattern subsequently started to increase for the next six months (Figure 4). *M. lyrata* population showed decreasing pattern in April 2014 after achieving the highest peak in March.

CI for *M. lyrata* showed significantly positive and negative correlations ($p<0.05$) to the GI value and ammonia nitrogen concentration, respectively (Table 1). Correlation between CI and GI was clearly shown in the graph pattern (Figure 5) depicting a decrease from June to September 2013 and an increase and decrease for October and November 2013, respectively. The trend of CI and GI also showed an increase from December 2013 to March 2014 and a decrease in April 2014.

Monthly pattern of ammonia nitrogen concentration for *M. lyrata* habitat was contradictory to the CI pattern (Figure 6). The first four months (May, June, July and August) indicated increasing ammonia nitrogen concentrations at 0.103±0.04, 0.127±0.03, 0.137±0.07 and 0.163±0.02 mg/L, respectively, while the CI values for *M. lyrata* decreased during these months. In September,

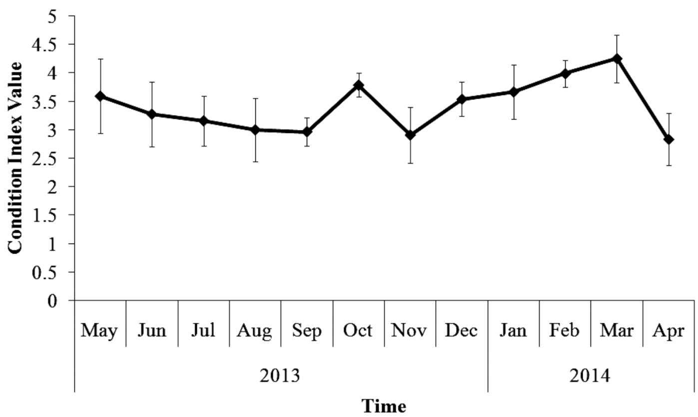

FIGURE 3. Temporal CI for *Meretrix lyrata* (mean±standard deviation)

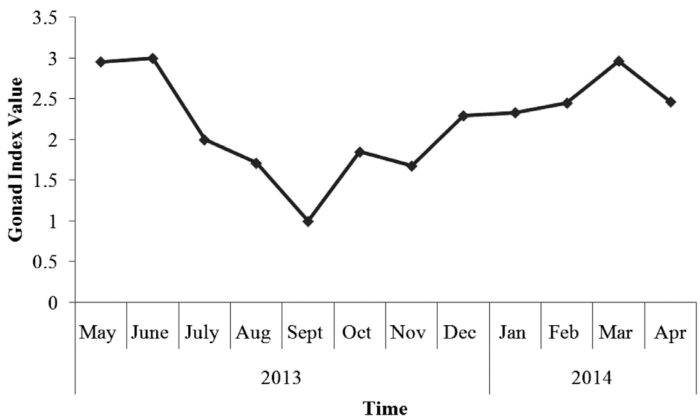

FIGURE 4. Monthly GI of *Meretrix lyrata*

TABLE 1. Pearson correlation analysis of CI with GI of *Meretrix lyrata* and different water parameters at the Buntal village

Parameters	Mean±Std	r	Significant (2-tailed)
pH	7.42±0.55	0.327	0.3
Total Dissolved Solid (mg/L)	42.04±4.45	-0.497	0.1
Salinity (PSU)	27.10±2.70	-0.470	0.123
Temperature (°C)	26.60±0.60	0.476	0.486
Conductivity (μS/cm))	4.03±0.39	-0.521	0.082
Dissolved Oxygen (mg/L)	4.46±0.52	0.277	0.383
Total Rainfall (mm)	322.1±161.1	-0.046	0.887
Ammonia Nitrogen (mg/L)	0.12±0.06	-0.613*	0.034*
Nitrite (mg/L)	0.01±0.00	-0.324	0.305
Nitrate (mg/L)	0.80±0.30	-0.283	0.372
Phosphate (mg/L)	0.19±0.11	-0.213	0.506
Total Suspended Solid (g/L)	0.08±0.03	-0.335	0.287
Chlorophyll a (mg/m^3)	6.21±5.88	0.94	0.102
Gonad Index (GI)	2.22±0.61	0.639	0.025*

*Correlation is significant at the 0.05 level (2 tailed)

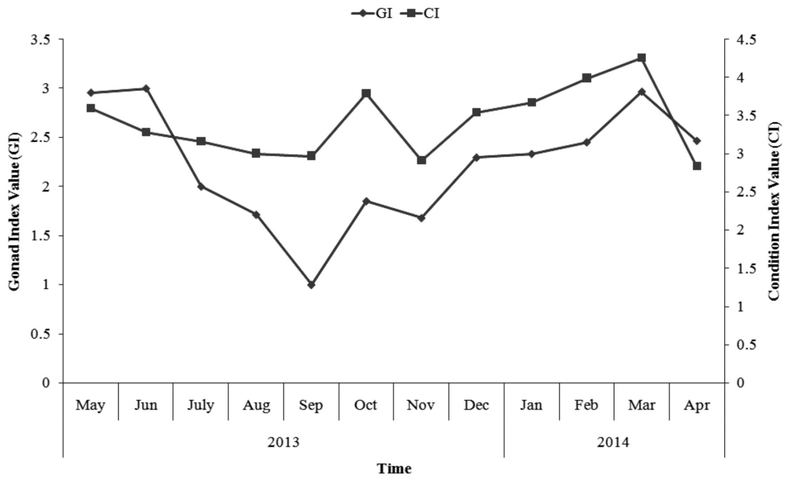

FIGURE 5. Monthly correlations between CI and GI of *Meretrix lyrata*

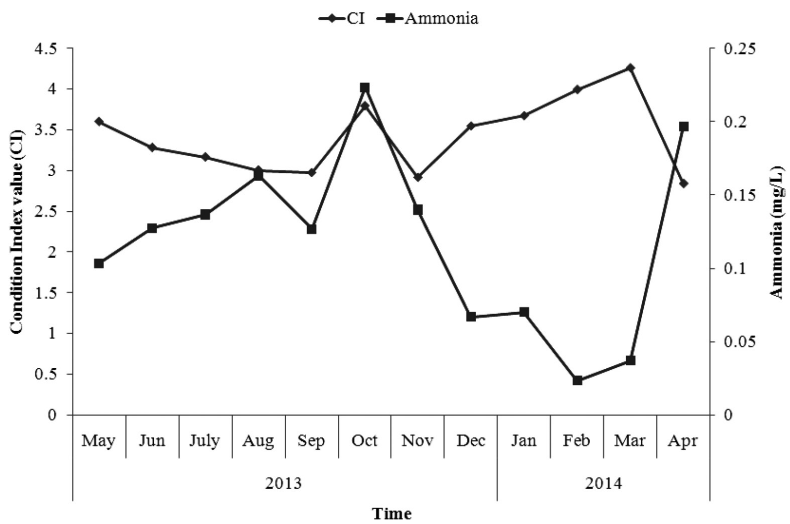

FIGURE 6. Monthly correlation graph between CI and ammonia nitrogen concentration in seawater

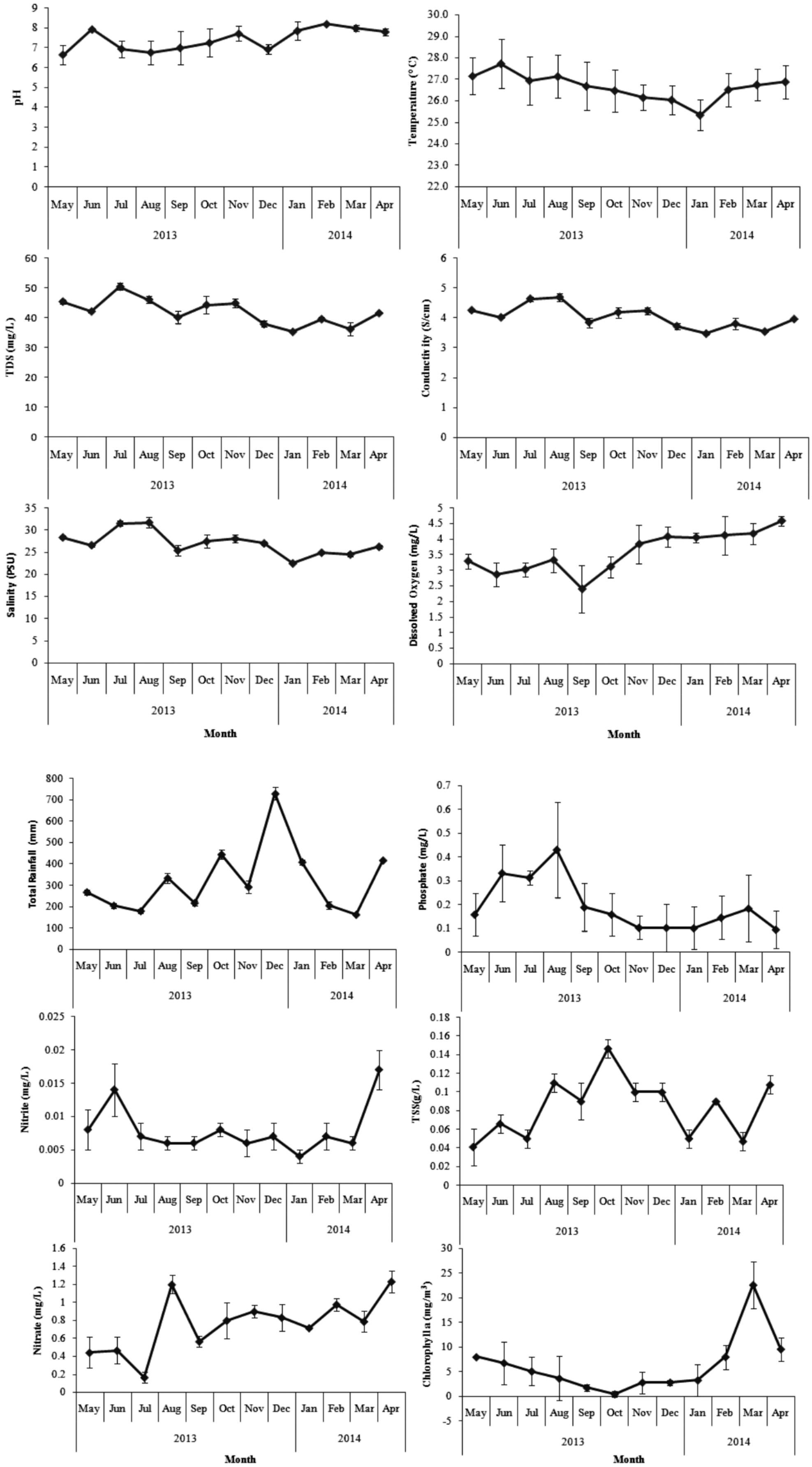

FIGURE 7. Monthly water parameters in the natural habitat of *Meretrix lyrata* (mean±standard deviation)

ammonia nitrogen concentration decreased slightly (0.127±0.02 mg/L) while in October the ammonia nitrogen concentration (0.223±0.06 mg/L) increased significantly with the increase in CI value. The ammonia nitrogen then decreased moderately from the early of November (0.14±0.03 mg/L) until February (0.023±0.02 mg/L), which was the lowest ammonia nitrogen concentration in seawater. The ammonia level in March (0.037±0.01 mg/L) and April (0.197±0.04 mg/L) was considerably higher while *M. lyrata* attained the lowest CI value.

A total of 12 water parameters such as hydrogen ion concentration (pH), total dissolved solid (TDS), salinity, temperature, conductivity, dissolved oxygen (DO), total rainfall, nitrite, nitrate, phosphate, total suspended solid (TSS) and chlorophyll *a* were recorded but they did not show any meaningful correlation with the monthly CI value (Figure 7).

Discussion

The range of CI for this study (2.839-4.258%) falls within the range of previous studies on *Meretrix* species (Adjei-Boateng & Wilson 2013). The CI for *M. lyrata* was higher (2.5-4.3%) compared to the previous study on *M. casta* from India (Sophia & Balasubraniam 1992). However, the CI values for *M. lyrata* was lower than *M. meretrix* from Korampallam, India (Narasimham et al. 1988) and *M. casta* from Shirakawa flat, Japan (Nakamura et al. 2005). High CI value in May and October 2013 and March 2014 indicated maturing of the *M. lyrata* population and it was at the initial spawning stage based on the GI value. Adjei-Boateng and Wilson (2013) reported that the bivalve *Galatea paradoxa* had high CI value during gametogenesis when it was at the ripe and initial spawning stages. The *M. lyrata* population was found with the lowest CI value in September, November and April and this indicated that the population was at spent and resting stages during this period. A similar observation was also noted in *M. casta* and *M. meretrix* (Narasimham et al. 1988; Rao 1988).

The CI value does not correspond only to reproductive changes. Other factors such as water parameters may affect the flesh quality of *M. lyrata*. Ammonia nitrogen concentration in coastal seawater attributing to the decomposition of organic matter from metabolic waste of macrofauna or domestic wastes from nearby villages directly affect the CI value of *M. lyrata*. In this study, the CI value was negatively correlated with the ammonia nitrogen concentration. Furthermore, bivalve *Mytilus edulis* excretes ammonia nitrogen into the environment as part of their metabolic process and high densities of bivalve in a particular habitat may cause the concentration of ammonia nitrogen to increase (Strain 2002). High concentration of ammonia nitrogen in the seawater may cause stress to the bivalve and this would trigger the acclimatization mechanisms which reduce energy and nutrient consumption and eventually decrease growth (Gosling 2003; Sobral & Fernandes 2004).

Growth and gonad development require food and nutrients for energy utilization and these can be determined through the CI value (Darriba et al. 2005; King et al. 1986; Nakamura et al. 2010). The source and quantity food filtered by bivalves depends on the amount of suspended food particles (phytoplankton) that are transported by water currents in the aquatic environment. According to Hua et al. (2013), bivalves get insufficient food at the low water velocity. We did not record any data on the water velocity at the *M. lyrata* environment. However, Hayden and Woods (2011) reported that bivalve size decreases when water velocity is low and this may cause insufficient food to the bivalve. Sufficient food is also an important factor that increases the gonad development of the bivalve due to high energy needed for the process. Furthermore, water current such as wave can increase the dissolved oxygen in the seawater and it is important for the growth of bivalve (Dobson & Frid 2008; Lewis & Ceratto 1997). The presence of parasites in clams may have a deleterious effect on their nutrition, which in turn influences the CI value, shell growth and foot length in clam (O'Connell-Milne et al. 2016). There is no documentation on parasite infection to the local *M. lyrata*, however, *Perkinsus marinus* is a parasite found infecting *M. meretrix* from the Merambong shoal, Johor (Azmi et al. 2014). This parasite is mostly infecting digestive glands, gills and gonads of *M. meretrix* (Abdel-Baki et al. 2014; Azmi et al. 2014). The infected tissue will be degraded by the parasite which causes the bivalve to lose in weight (Ray 1954). In addition, the parasite also may cause iron deficiency in the hemocytes of bivalve (Soudant et al. 2013).

Conclusion

In this study, CI was used as a method to predict the maturity and spawning season for *M. lyrata*. This prediction method was also supported by ammonia nitrogen concentration in the seawater which was found to be correlated with the spawning season of *M. lyrata*. The high CI indicated that *M. lyrata* was at mature and spawning stages and it is important to suspend harvesting activities until the end of the spawning season. This method, which is inexpensive and fast, can be easily applied by aquaculturists and fishermen to determine the maturity *M. lyrata* and other bivalves as compared to conventional histological techniques.

Acknowledgements

The authors would like to acknowledge the Ministry of Education Malaysia for the financial support under the research grant FRGS 5524237. The authors would also like to thank the Deanery and staff from the Department of Animal Science and Fishery, Faculty of Agriculture and Food Sciences, Universiti Putra Malaysia Bintulu Sarawak Campus for technical, logistical and facilities support, which made this study possible.

REFERENCES

Abdel-Baki, A-A.S., Al-Quraishy, S., Dakhil, M.A., Oliveira, E., Casal, G. & Azevedo, C. 2014. *Perkinsus* sp. (Alveolata: Perkinsidae) from Arabian Gulf: Ultrastructural observation of the trophozoites and the cellular response of the host. *ACTA Protozoologica* 53: 215-221.

Adjei-Boateng, D. & Wilson, J.G. 2013. Body condition and gametogenic cycle of *Galatea paradoxa* (Mollusca: Bivalvia) in the Volta River Estuary, Ghana. *Estuarine Coastal and Shelf Science* 132: 94-98.

Azimah, A.R., Idris, M.H., Abu Hena, M.K., Wong, S.K. & Arshad, A. 2013. Analysis of condition index in *Polymesoda expansa* (Mousson, 1849). *Pakistan Journal of Biological Sciences* 15(13): 629-634.

Azmi, N., Mazlan, A.G. & Zaidi, C.C. 2014. Apicomplexa-like parasites of economically important bivalves from Merambong shoal, Johor. *Malayan Nature Journal* 66(1&2): 108-120.

Broom, M.J. 1985. The biology and culture of marine bivalves molluscs of genus *Anadara*. *ICLARM Studies and Reviews* 12: 37.

Ceballos-Vazquez, B.P., Arellani-Martinez, M., Garcia-Dominguez, F. & Villalejo-Fuerte, M. 2000. Reproductive cycle of rugosa pen shell *Pinna rugosa*, Sowerby, 1835 (Mollusca: Bivalvia) from Bahia Concepcion, Gulf of California and its relation to temperature and photoperiod. *Journal of Shellfish Research* 19(1): 95-99.

Davenport, J. & Chen, X. 1987. A comparison of methods for the assessment of condition in mussel (*Mytilus edlis* L.). *Journal of Molluscan Study* 53: 293-297.

Darriba, S., Juan, F.S. & Guerra, A. 2005. Energy storage and utilization in relation to the reproductive cycle in the razor clam *Ensis arcuatus* (Jeffreys, 1865). *ICES Journal of Marine Science* 62: 886-896.

Dobson, M. & Frid, C. 2008. *Ecology of Aquatic System*. 2nd ed. Oxford: Oxford University Press.

Gosling, E. 2003. *Bivalve Mollusc: Biology, Ecology and Culture*. New York: Wiley-Blackwell.

Hamli, H., Idris, M.H., Abu Hena M.K. & Wong, S.K. 2012. Taxonomic study of edible bivalve from selected division of Sarawak. *International Journal of Zoological Research* 8(1): 52-58.

Hayden, B.J. & Woods, C.M.C. 2011. Effect of water velocity on growth and retention of cultured Greenshell™ mussel spat, *Perna canaliculus* (Gmelin, 1791). *Aquaculture International* 19: 957-971.

Hua, D., Neves, R.J. & Jiao, Y. 2013. Effects of algal density, water flow and substrate type on culturing juveniles of the rainbow mussel (*Villosa iris*) (Bivalvia: Unionidae) in a laboratory circulating system. *Aquaculture* 416-417: 367-373.

Humason, G.L. 1972. *Animal Tissue Technique*. 4th ed. San Francisco, CA.: W.H. Freeman Co.

King, C.A., Langdon, C.J. & Counts, C.L. 1986. Spawning and early development of *Corbicula fluminea* (Bivalvia: Corbiculidae) in laboratory culture. *American Malacological Bulletin* 4(1): 81-88.

Lewis, D.E. & Cerrato, R.M. 1997. Growth uncoupling and the relationship between shell growth and metabolism in the soft shell clam *Myra arenaria*. *Marine Ecology Progress Series* 158: 177-189.

Marcado-Silva, N. 2005. Condition index of the eastern oyster *Crasosstrea virginica* (Gmelin, 1791) in Sapelo Island Georgia-Effects of site, position on bed and Pea crab parasitism. *Journal of Shellfish Research* 24(1): 121-126.

Nakamura, Y., Hashizume, Koyama, K. & Tamaki, A. 2005. Effects of salinity on sand burrowing activity, feeding and growth of the clams *Mactra veneriformis, Ruditapes philippinarum* and *Meretrix lusoria*. *Journal of Fisheries Research* 24(4): 1053-1059.

Nakamura, Y., Nakano, T., Yurimoto, T., Maeno, Y., Koizumi, T. & Tamaki, A. 2010. Reproductive cycle of venerid clam *Meretrix lusoria* in Ariake Sound and Tokyo Bay, Japan. *Fisheries Science* 76: 931-941.

Narasimham, K.A., Muthiah, P., Sandarajan, D. & Vaithinathan, N. 1988. Biology of the great clam, *Merertrix meretrix* in the Korampallam Creek, Tuticorin. *Indian Journal of Fisheries* 35(4): 288-293.

O'Connell-Milne, S.A., Poulin, R., Savage, C. & Rayment, W. 2016. Reduce growth, body condition and foot length of the bivalve *Austrovenus stutchburyi* in response to parasite infection. *Journal of Experimental Marine Biology and Ecology* 474: 23-28.

Rao, G.S. 1988. Biology of *Meretrix casta* (Chemnitz) and *Paphia malabarica* (Chemnitz) from Mulky Estuary, Dakshina, Kannada. *National Seminar on Shellfish Resources and Farming*. pp. 148-153.

Ray, S.M. 1954. Biological studies of *Dermocystidium marinum*. Rice Institute Pamphlet, Special Issue The Rice Institute, Houston, Texas.

SAS Institute Inc. 2004. *SAS ODBC Driver 9.1: User's Guide and Programmer's Reference*. Cary, NC: SAS Institute Inc.

Sobral, P. & Fernandes, S. 2004. Physiological responses and scope for growth of *Ruditapes decussatus* from Ria Formosa, southern Portugal, exposed to increased ambient ammonia. *Scentia Marina* 67(2): 219-225.

Sophia, A.J.A. & Balasubramanian, T. 1992. Changes in the physical condition of *Meretrix casta* exposed to water soluble fractions of refined and crude oil. *Archives of Environmental Contamination and Toxicology* 22: 471-474.

Soudant, P., Chu, F-L.E. & Volety, A. 2013. Host-parasite interactions: Marine bivalve mollusc and protozoan parasites, *Perkinsus* species. *Journal of Invertebrate Pathology* 114: 196-216.

Strain, P.M. 2002. Nutrient dynamic in ship harbour Nova Scotia. *Atmosphere-Ocean* 40(1): 45-58.

Yolye, V. 1975. The habitat and functional anatomy of the West African bloody cockle *Anadara senilis* (L). *Proceedings of the Malacological Society of London* 41: 277-299.

Department of Animal Science and Fishery
Faculty of Agriculture and Food Sciences
Universiti Putra Malaysia Bintulu Sarawak Campus
Nyabau Road, P.O. Box 396
97008 Bintulu, Sarawak Bumi Kenyalang
Malaysia

*Corresponding author; email: hadihamli@gmail.com

Received: 28 August 2014
Accepted: 10 September 2016