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Biometric study of the freshwater mussel *Sinanodonta woodiana* in the Lahambuti River, Konawe Regency, Southeast Sulawesi

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ABSTRACT

Sinanodonta woodiana is one of the introduced mussel species in the Lahambuti River (Konawe Regency, Southeast Sulawesi), whose biometric characteristics had not been fully understood. This study aimed to determine the biometric characteristics, including the length-weight relationship and condition index of the mussel. The research was conducted over 12 months from 2021 to 2022 in two series: May–October 2021 and February–July 2022. Mussel samples were collected using a scoop within 1×1 m² transects, with 10 replicates each month. The collected mussels were brought to the laboratory to measure shell length, total weight, and tissue weight using a caliper and a digital scale with accuracies of 0.5 cm and 0.01 g. The shells and soft tissues were dried in an oven at 70°C for 48 hours and weighed using an analytical balance with 0.0001 g precision. The biometric data were analyzed using standard formulas. The results showed a mean *b* value of 2.80 with a coefficient of determination (R^2) of 93.52%. A t-test ($\alpha = 0.05$) indicated that the *b* value differed significantly from 3.0, suggesting a negative allometric growth. Monthly *b* values ranged from 2.31 (September) to 3.16 (May), with R^2 values from 91.11% to 96.66%. The average condition index was 3.25 ± 1.30, increasing with shell length and peaking in February (4.45 ± 1.47). It decreased from March to July, with the lowest value in June (2.09 ± 0.71). In conclusion, *S. woodiana* showed negative allometric growth and seasonal variation in condition index.

Keywords: Condition index, Lahambuti River, Length-weight relationship, *Sinanodonta woodiana*

INTRODUCTION

The area of freshwater mussel *Sinanodonta woodiana* is one of the mussel species introduced into the Lahambuti River, Southeast Sulawesi (Purnama *et al.* 2019). This species originated from the Yangtze and Heilongjiang Rivers in China and later spread to relatively calm waters such as ponds and lakes (Donrovich *et al.* 2017). It has invaded almost all continents, including many countries in Asia (Ercan *et al.* 2013), such as Indonesia (Java and Sumatra) (Watters, 1997), Sulawesi (Purnama *et al.* 2019; Tampa *et al.* 2014), Europe (Colomba *et al.* 2013), and North America (Raley *et al.* 2011), through transmission via host fish such as tilapia (Dobler *et al.* 2022; Watters, 1997), although over the past few decades, this species has declined by up to 70% in some areas of its native range due to the loss of its host fish (Liu *et al.* 2010). These mussels are found far from estuaries and inhabit the rhithral segment of the river. *S. woodiana* lives at the bottom of water bodies and buries itself in muddy substrates. In addition, the species occurs in slow-flowing, euphotic, and relatively shallow rivers (Moëzzi *et al.* 2017). Like other freshwater mussels, *S. woodiana* plays an important ecological and economic role. In aquatic ecosystems, mussels can act as ecosystem engineers (Bódis *et al.* 2014a, 2014b). They are capable of modifying substrate structure, purifying water, and providing substrate/habitat for other aquatic biota (Vaughn, 2018).

These mussels are also considered ideal bioindicators for monitoring pollution levels in aquatic environments (Chen *et al.* 2012; Li *et al.* 2015; Reichard *et al.* 2012), due to their sedentary lifestyle, high bioaccumulation of metals and pesticide contaminants in their soft tissues and shells (Yancheva *et al.* 2016; Zhang *et al.* 2014),

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thereby linking pollutant content between organisms and habitats (Van Hassel and Farris, 2006; Yang *et al.* 2008).

Economically, this species has been used as food (Chen *et al.* 2012). In several countries, such as Poland, the mussels serve as food for various animals (Andrzejewski *et al.* 2013), for cultured pearl production in Tuscany (Liu *et al.* 2014), and as a source of antitumor agents (Liu *et al.* 2008; Vaughn, 2018) and traditional Chinese medicine for diabetes (Liu *et al.* 2008). They are also used for genotoxicity monitoring (Ciparis *et al.* 2015), while the bioaccumulation of calcium, phosphorus, and heavy metals in the soft tissues and shells of *S. woodiana* has been widely studied (Królak and Zdanowski, 2001, 2017).

Shell size in relation to biometric parameters can be a reliable tool for monitoring population dynamics and aquatic environmental conditions (Bayne and Newell, 1983; Deidun et al. 2014; Palmer, 1990). These parameters can be transformed into various indices for evaluation purposes (Akinjogunla and Moruf, 2018; Türker et al. 2019). One of the most common tools used to interpret data on aquatic biota such as mussels is the length–weight relationship. This relationship reflects the growth and allometric patterns between length and weight, which may provide information about reproductive conditions, including sex categories and developmental stages (Akinjogunla and Moruf, 2018; Rueda and Urban, 1998), population density (Seed, 1968), and the physical and biological characteristics of aquatic environments (Thorarinsdottir and Johannesson, 1996), including the quality and quantity of food (Akinjogunla and Moruf, 2020).

Similarly, the condition factor indicates the health status of mussels in their habitats and is expressed by the "condition coefficient". This coefficient reflects ecological and biological factors such as gonadal stages, fitness levels, and environmental suitability for food acquisition (Gomiero and Braga, 2005).

Based on a literature review, only a few studies have examined biometric aspects of length–weight relationships and condition factors of *S. woodiana*. These include a morphometric study of Taiwanese mussels in Minahasa and North Minahasa Districts (Tampa *et al.* 2014), variation in the shell form of the swan mussel *Anodonta cygnea* (Linnaeus, 1876) in response to water current (Moëzzi *et al.* 2017), a morphometric and genetic comparison of *S. woodiana* populations: "Does shape really matter?" (Guarneri, 2014), and morphometric studies on the *Anodonta anatina* bivalve population from Dognecea Lake (Bura *et al.* 2011). This study aimed to determine biometric characteristics including the length–weight relationship and condition index of *S. woodiana* mussels in the Lahambuti River, Konawe Regency, Southeast Sulawesi.

MATERIAL AND METHOD

The study was conducted over the course of one year in two phases: the first phase took place from May to October 2021, and the second phase from February to July 2022. The research site was located in the Lahambuti River, Konawe Regency, Southeast Sulawesi, at coordinates 03°55'56.63" S - 122°10'11.20" E to 03°56'33.49" S - 122°10'19.00" E (Figure 1).

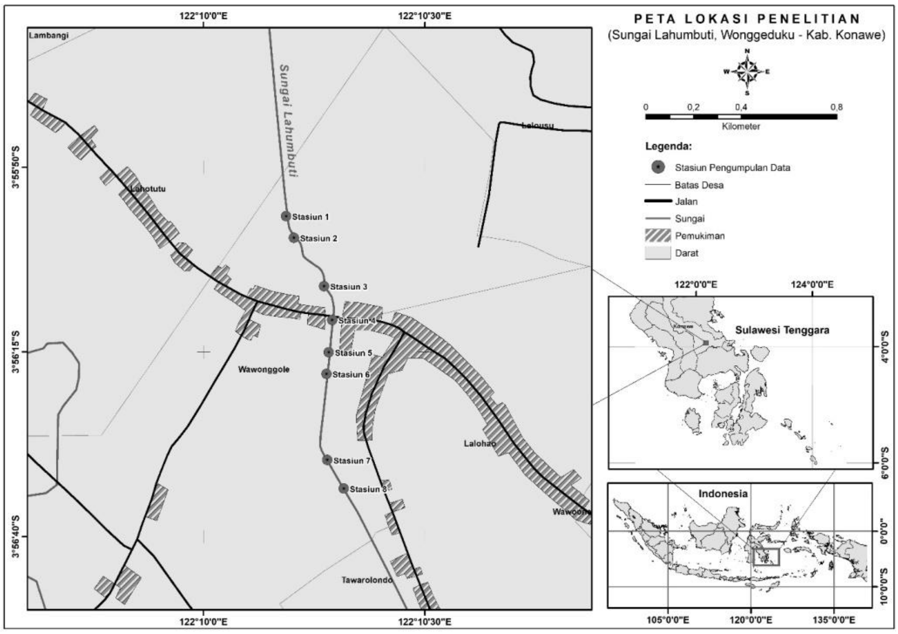


Figure 1. Map of the mussel sampling site in the Lahambuti River, Konawe Regency, Southeast Sulawesi.

The mussels were collected monthly using a scoop from the riverbed substrate at a depth of 20 cm, within a 1 × 1 m^2 quadrat, repeated 10 times. All collected samples were transported to the Prolink Laboratory, Faculty of Fisheries and Marine Science (FPIK) Halu Oleo University, for biometric measurements. Shell length, wet weight, and tissue weight were measured using a caliper and a digital balance, with accuracies of 0.5 cm and 0.01 g, respectively. Both the soft tissues and shells were oven-dried at 70°C for 48 hours. After drying, the samples were weighed using an analytical balance with an accuracy of 0.0001 g.

Data Analysis

The length-weight relationship was analyzed to determine the coefficient b using the equation described by (Bahtiar *et al.* 2014):

$$W = aL^b$$

where:
W = the total weight (g)
L = the shell length (cm)
a and *b*= constants

Size classes were determined using Sturges' formula (Sturges, 1926) as outlined by Bahtiar *et al.* (2014) and Taula *et al.* (2022):

$$K = 1 + 3.3 \log$$

and

$$B = \frac{ba - bb}{K}$$

where:
K = the number of size classes
N = the number of samples
B = the class interval
ba = the upper class limit
bb = the lower class limit

The mussel condition index was calculated following Rahim *et al.* (2012):

$$IK = \frac{BDK}{BC} x100$$

where:
IK = the condition index
BDK = the dry meat weight (g)
BC = the shell weight (g)

The condition index was interpreted as follows: IK < 2 = underweight, 2–4 = moderate, and ≥ 4 = overweight.

RESULT AND DISCUSSION

Result

Length-Weight Relationship

The mean *b* value for male *Sinanodonta woodiana* mussels in the Lahambuti River was 2.80, with a coefficient of determination (R^2) of 93.52 (Figure 2A). A t-test (α = 0.05) indicated that the *b* value was significantly different from 3.0 (*b* < 3.0). Temporally, *b* values tended to fluctuate (Figure 2B). Values below 3.0 were predominantly observed in most months, except in July, March, and May, where *b* values exceeded 3.0. The lowest *b* value was recorded in September (2.31), while the highest was found in May (3.16), with coefficients of determination of 94.72 and 9.66, respectively (Figure 2C). The t-test results showed that *b* values in May–August 2021 and March 2022 were not significantly different from 3.0, whereas the *b* value in May 2022 was significantly different context from 3.0 (*b* > 3.0).

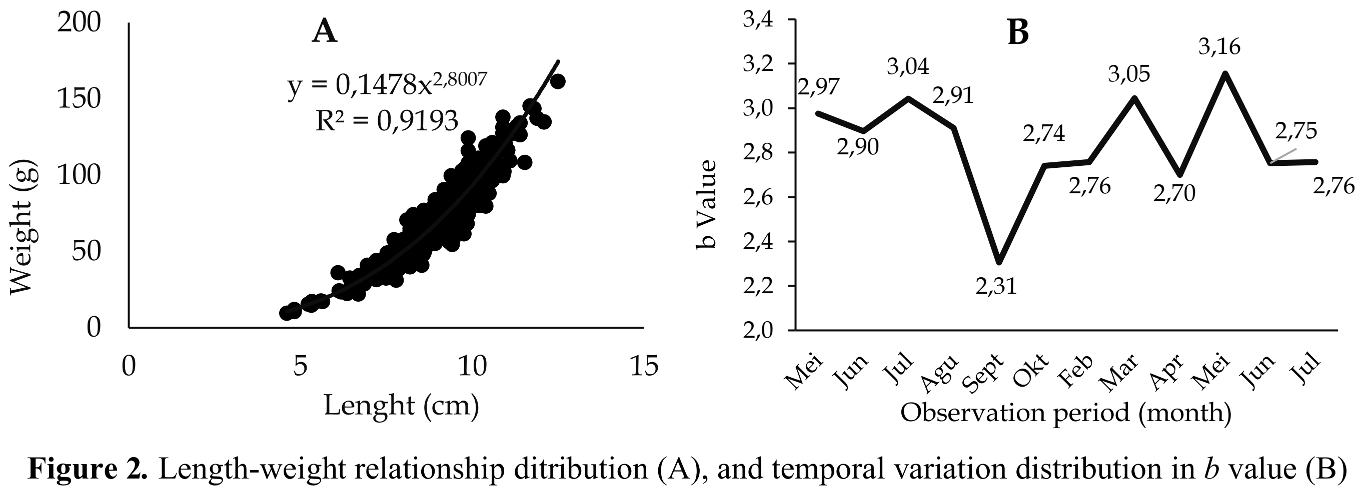
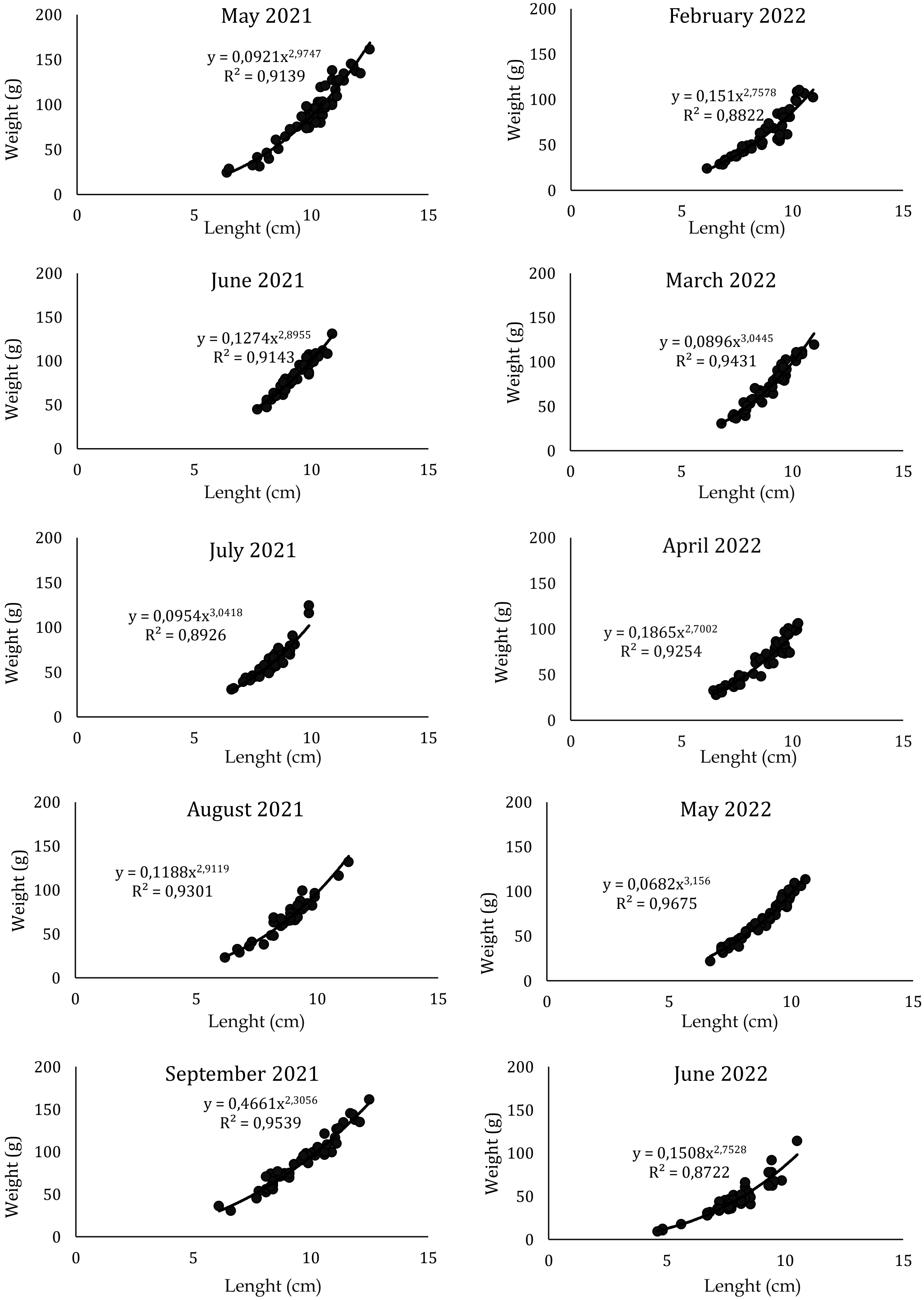


Figure 2. Length-weight relationship ditribution (A), and temporal variation distribution in *b* value (B) of *Sinanodonta woodiana* mussels in the Lahambuti River.

C


May 2021
y = 0,0921x^2,9747
R^2 = 0,9139
February 2022
y = 0,151x^2,7578
R^2 = 0,8822
June 2021
y = 0,1274x^2,8955
R^2 = 0,9143
March 2022
y = 0,0896x^3,0445
R^2 = 0,9431
July 2021
y = 0,0954x^3,0418
R^2 = 0,8926
April 2022
y = 0,1865x^2,7002
R^2 = 0,9254
August 2021
y = 0,1188x^2,9119
R^2 = 0,9301
May 2022
y = 0,0682x^3,156
R^2 = 0,9675
September 2021
y = 0,4661x^2,3056
R^2 = 0,9539
June 2022
y = 0,1508x^2,7528
R^2 = 0,8722
Weight (g)
Lenght (cm)
0
50
100
150
200
0
5
10
15

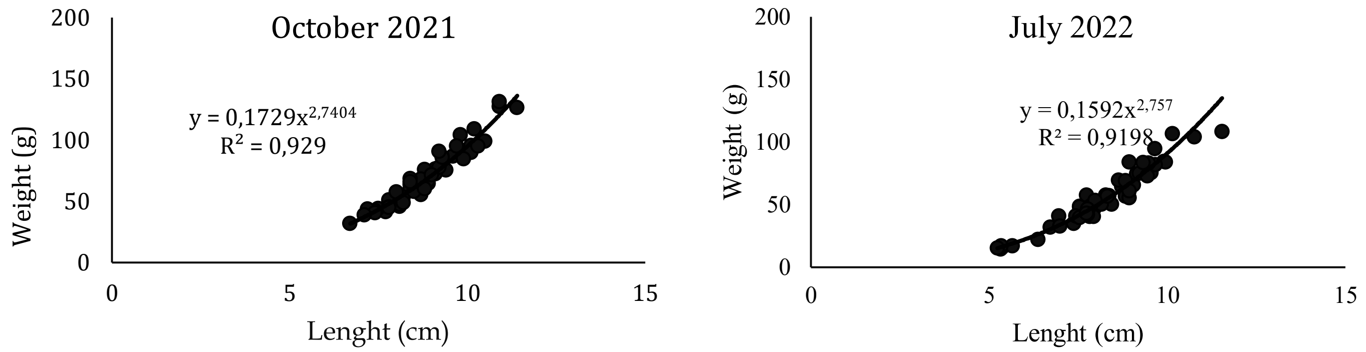


Figure 2. Temporal coefficient of determination poin (C) for *S. woodiana* mussels in the Lahambuti River, Konawe Regency, Southeast Sulawesi.

Condition Index

The mean condition index of *S. woodiana* mussels in the Lahambuti River was 3.25 ± 1.30. The condition index tended to increase from the smallest size class (4.61–5.27 cm) up to the 5.95–6.61 cm class. It then declined toward the 9.30–9.96 cm size class. The condition of index sub sequently increased again in the highest size class interval (Figure 3A). Temporally, the condition of index tended to increase from July to August 2021. The highest condition index was observed in February and then steadily declined through July 2022 (Figure 3B).

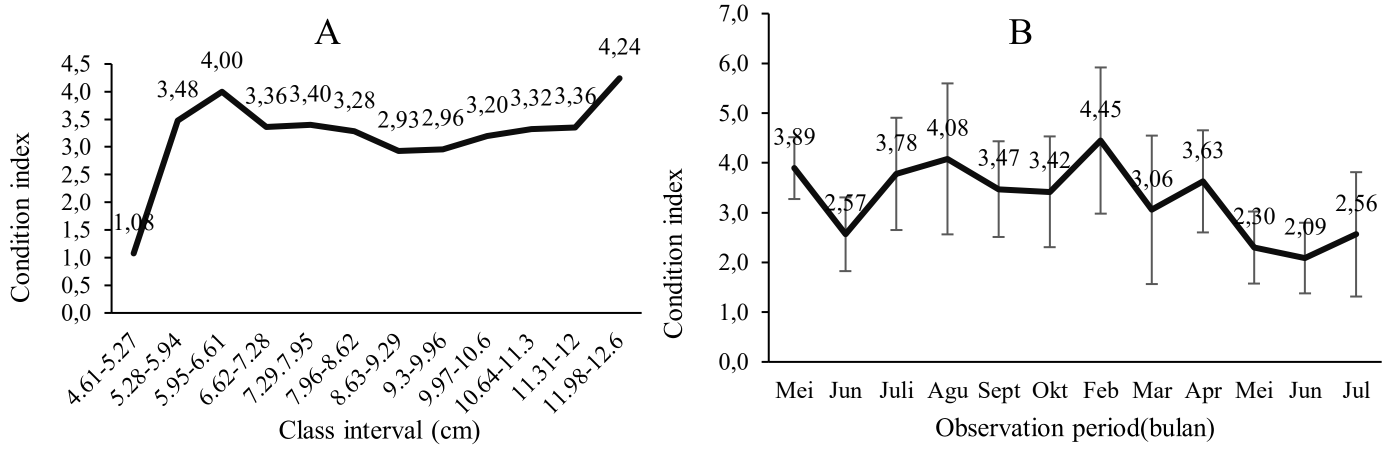


Figure 3. Condition index of *S. woodiana* mussels based on size class intervals (A) and sampling period (B) in the Lahambuti River, Konawe Regency, Southeast Sulawesi.

Discussion

Length-Weight Relationship

The average *b* value of *Sinanodonta woodiana* in the Lahambuti River indicates a negative allometric growth pattern. This suggests that shell length increases more rapidly than body weight, meaning the mussels in this river are relatively thin. This *b* value is comparable to that of other mussel species within the same genus, such as *Anodonta cygnea*, which has a *b* value of 0.8561 (Moëzzi *et al.* 2017). Similarly, other freshwater mussels exhibit negative allometric growth, including *Lamellidens corrianus* (*b* = 2.67) (Mondol *et al.* 2016), *Hyriopsis myersiana* (*b* = 2.64–2.97) (Uthaiwan *et al.* 2001), *Batissa violacea* (*b* = 2.45–3.03 and 2.46–2.94 for males and females, respectively) (Bahtiar *et al.* 2023), *Corbicula moreletiana* (*b* = 1.27–2.32) (Ngor *et al.* 2018), *Galatea paradoxa* (*b* = 2.39–2.85 (Kingdom and Azagba, 2017), and *Synodontis resupinatus* (*b* = 2.19) (Adeyemi *et al.* 2009).

However, the *b* value observed in the Lahambuti River is lower than those reported for other freshwater mussels such as *Parreysia favidens* (*b* = 3.06) (Ramesha and Sophia, 2015) and *Geloina expansa* (*b* = 3.31) (Argente and Ilano, 2021). Temporally, the *b* value of *S. woodiana* fluctuated monthly. Most months recorded *b* values below 3.0, except for July, March, and May, which had values exceeding 3.0. The lowest *b* value (2.31) was observed in September, while the highest (3.16) occurred in May. Monthly fluctuations in b values have also been observed in other species, such as *Parreysia corrugata* (*b* = 2.60–3.10) (Ramesha and Thippeswamy, 2009) and *Galatea paradoxa* (*b* =

2.023–3.874) (Obirikoran *et al.* 2013).

In general, *b* values below 3.0 indicate a non-isometric growth pattern across most months, a trait commonly observed in bivalves throughout their life cycle (Ngor *et al.* 2018). The fluctuating *b* values of *S. woodiana* in the Lahambuti River may be associated with various factors such as water quality (Nakaoka, 1992), food availability (Gaspar *et al.* 2002; Lim *et al.* 2020; Trisyani *et al.* 2016), and reproductive cycles (Obirikoran *et al.* 2013; Thippeswamy *et al.* 2014).

A decline in *b* value may result from deteriorating water quality caused by sand mining and runoff from mining areas, which increases turbidity and reduces the mussels' filtration efficiency. In contrast, higher *b* values may be linked to: (1) the increase in vitellogenesis during gonad maturation, (2) egg incubation within demibranchs until the D-larval stage typical in freshwater mussels, including *S. woodiana*, and (3) elevated levels of organic matter and phytoplankton during certain months (Bahtiar *et al.* 2021), as well as greater water surface area due to rising water levels during the rainy season (Ngor *et al.* 2018).

Condition of Index

The condition of index (CI) of *S. woodiana* in the Lahambuti River was found to be 3.25 ± 1.30, which falls within the moderate category (Abu-Zaid *et al.* 2014). This value is relatively lower compared to several other freshwater mussels, such as *Lamellidens corrianus* with a CI of 13.74 ± 3.32 (Mondol *et al.* 2016), *Parreysia favidens* with values ranging from 4.16 to 16.36 (Ramesha & Sophia, 2015), and *Batissa violacea* from the Laeya River, categorized as plump, with values ranging from 3.58 ± 1.66 to 6.00 ± 3.07 for males and 3.26 ± 1.29 to 7.83 ± 2.55 for females, respectively (Bahtiar *et al.* 2023).

Although the average CI of *S. woodiana* was within the moderate category, it showed temporal variation, reaching the plump category during August and February. A similar pattern was reported in *Geloina erosa* from the Mahakam Delta, Kalimantan, which showed CI values ranging from moderate to plump (3–4) (Rizal, 2010).

The CI of mussels can vary across regions and is influenced by several factors, including body size, seasonal changes (Micklem *et al.* 2016), water quality (Duinker *et al.* 2008), and food availability (Krampah *et al.* 2016). In the Lahambuti River, the CI showed a size-related trend: it increased from the smallest size class (4.61–5.27 cm) to 5.95–6.61 cm, then declined up to 9.30–9.96 cm, before increasing again in the largest size classes. Temporally, CI values increased from July to August 2021, peaked in February, and gradually declined until July 2022. These temporal variations in CI are likely influenced by seasonal shifts affecting food availability, water quality, and gonadal maturation.

The development and maturation of gonads in freshwater mussels, including *S. woodiana*, occur throughout the year. However, increases in CI are typically observed during peak gonadal maturity and egg storage within the demibranchs, especially at the D-type larval stage (Denton *et al.* 2012). In contrast, the release of pediveliger larvae from the incubation chamber is associated with a decline in CI (Cataldo *et al.* 2001).

CONCLUSION

This study reveals that *Sinanodonta woodiana* in the Lahambuti River exhibits negative allometric growth, with *b* values generally below 3.0. The growth pattern fluctuates monthly and is influenced by environmental factors and reproductive cycles. The condition index also varies across size classes and observation periods, indicating changes in physiological condition likely related to food availability, water quality, and reproductive maturity. These findings demonstrate that growth and condition patterns of *S. woodiana* are closely linked to both environmental dynamics and biological processes.

REFERENCES

Abu-Zaid MMT, Razek FAA, Aziz TA, Abdel-Gaid SE. 2014. Studies on the various allometric relationships in the intertidal horse mussel *Modiolus auriculatus* of the Red Sea, Egypt. *Blue Biotechnology Journal*. 3: 1–10.

Adeyemi SO, Adikwu AI, Bankole NO. 2009. The length-weight, length-length relationship and condition factor of *Synodontis Resupinatus* in Gbedikere Lake Bassa, Kogi State, Nigeria. *Continental Journal Agricultural Science*. 3: 21–26.

Akinjogunla VF, Moruf O. 2018. The ecology and growth biology of *Farfantepenaeus notialis* (Pérez-Farfante, 1967) from an open tidal estuary in Nigeria. *Nigerian Journal of Fisheries*. 15(1): 1326–1335.

Akinjogunla VF, Moruf RO. 2020. Shell growth pattern and percentage flesh yield of the West African clam *Galatea paradoxa* (Born, 1778) from Itu Creek, Niger Delta, Nigeria.

Nigerian Journal of Basic and Applied Sciences. 27(2): 119–126. https://doi.org/10.4314/njbas.v27i2.16

Andrzejewski W, Urbańska M, Mazurkiewicz J, Gierszal H, Golski J. 2013. The current invasion status of *Anodonta woodiana* (Lea, 1934) in Poland — study of habitat parameters. *Oceanological and Hydrobiological Studies*. 42(2): 173–180. https://doi.org/10.2478/s13545-013-0071-1

Argente FAT, Ilano A. 2021. Population dynamics of mud clam *Polymesoda expansa* (Mousson 1849) (Bivalvia Corbiculidae) in Loay-Loboc River, Bohol, Philippines. *Journal of Sustainability Science and Management*. 16(3): 43–55. https://doi.org/10.46754/jssm.2021.04.004

Bahtiar, Anadi L, Nurgayah W. 2014. Studi morofometrik dan meristik kerang pokea (*Batissa violacea* var. *celebensis*, von Martens 1897) di Sungai Pohara Sulawesi Tenggara. *Jurnal Biologi Tropis*. 14(1): 36–44.

Bahtiar, Anadi L, Nurgayah W, Hamzah M, Hernawan UE. 2021. Reproductive biology of the freshwater clam pokea (*Batissa violacea* var. *celebensis*, von Marten 1897) (Bivalvia: Corbiculidae) in the Pohara River, Southeast Sulawesi, Indonesia. *Biotropia*. 28(1): 1–10. https://doi.org/10.11598/btb.0.0.0.623

Bahtiar B, Findra MN, Ishak E. 2023. Length-weight relationships and condition index of Pokea clams (*Batissa violacea* var. *celebensis*, von Martens 1897) in the Laeya River, Southeast Sulawesi, Indonesia. *Aceh Journal of Animal Science*. 8(2): 45–52. https://doi.org/https://doi.org/10.13170/ajas.8.2.30994

Bayne BL, Newell RC. 1983. Physiological energetics of marine molluscs. In *The Mollusca* (pp. 407–515). *Elsevier*. https://doi.org/10.1016/B978-0-12-751404-8.50017-7

Bódis E, Tóth B, Sousa R. 2014a. Massive mortality of invasive bivalves as a potential resource subsidy for the adjacent terrestrial food web. *Hydrobiologia*. 735(1): 253–262. https://doi.org/10.1007/s10750-013-1445-5

Bódis E, Tóth B, Szekeres J, Borza P, Sousa R. 2014b. Empty native and invasive bivalve shells as benthic habitat modifiers in a large river. *Limnologica*. 49: 1–9. https://doi.org/10.1016/j.limno.2014.07.002

Bura M, Muscalu-Nagy R, Hevesi C, Banatean-Dunea I. 2011. Morphometric studies on *Anodonta anatine* bivalve population from the Dognecea Lake. *Scientific Papers: Animal Science and Biotechnologies*. 4(2): 9–12.

Cataldo DH, Boltovskoy D, Stripeikis J, Pose M. 2001. Condition index and growth rates of field caged *Corbicula fluminea* (Bivalvia) as biomarkers of pollution gradients in the Paraná river delta (Argentina). *Aquatic Ecosystem Health & Management*. 4(2): 187–201. https://doi.org/10.1080/14634980127712

Chen X, Yang J, Liu H, Su Y, Sun L, Oshima Y. 2012. Element concentration is a unionid mussel (*Anodonta woodiana*) at different life stages. *Journal of the Faculty of Agriculture, Kyushu University*. 57: 139–144. https://doi.org/10.5109/22061

Ciparis S, Phipps A, Soucek DJ, Zipper CE, Jones JW. 2015. Effects of environmentally relevant mixtures of major ions on a freshwater mussel. *Environmental Pollution*. 207: 280–287. https://doi.org/10.1016/j.envpol.2015.09.023

Colomba MS, Liberto F, Reitano A, Grasso R, Di Franco D, Sparaco I. 2013. On the presence of *Dreissena polymorpha* (Pallas, 1771) and *Sinanodonta woodiana woodiana* (Lea, 1834) in Sicily (Mollusca Bivalvia). *Biodiversity Journal*. 4(4): 571–580.

Deidun A, Gianni F, Cilia DP, Lodola A, Savini D. 2014. Morphometric analyses of a *Pinctada radiate* (Leach, 1814) (Bivalvia: Pteriidae) population in the Maltese Islands. *Journal of Black Sea/Mediterranean Environment*. 20(1): 1–12.

Denton ME, Chandra S, Wittmann ME, Reuter J, Baguley JG. 2012. Reproduction and population structure of *Corbicula fluminea* in an oligotrophic Subalpine Lake. *Journal of Shellfish Research*. 31(1): 145–152. https://doi.org/10.2983/035.031.0118

Dobler AH, Hoos P, Geist J. 2022. Distribution and potential impacts of non-native Chinese pond mussels *Sinanodonta woodiana* (Lea, 1834) in Bavaria, Germany. *Biological Invasions*. 24(6): 1689–1706. https://doi.org/10.1007/s10530-022-02737-2

Donrovich SW, Douda K, Plechingerová V, Rylková K, Horký P, Slavík O, Liu H, Reichard M, Lopes-Lima M, Sousa R. 2017. Invasive Chinese pond mussel *Sinanodonta woodiana* threatens native mussel reproduction by inducing cross-resistance of host fish. *Aquatic Conservation: Marine and Freshwater Ecosystems*. 27(6): 1325–1333. https://doi.org/10.1002/aqc.2759

Duinker A, Håland L, Hovgaard P, Mortensen S. 2008. Gonad development and spawning in one and two year old mussels (*Mytilus edulis*) from Western Norway. *Journal of the Marine Biological Association of the United Kingdom*. 88(7): 1465–1473. https://doi.org/10.1017/S0025315408002130

Ercan E, Gaygusuz Ö, Tarkan AS, Reichard M, Smith C. 2013. The ecology of freshwater bivalves in the Lake Sapanca basin, Turkey. *Turkish Journal of Zoology*. 37: 730–738. https://doi.org/10.3906/zoo-1212-23

Gaspar MB, Santos MN, Vasconcelos P, Monteiro CC. 2002. Shell morphometric relationships of the most common bivalve species (Mollusca: Bivalvia) of the Algarve Coast (Southern Portugal). *Hydrobiologia*. 477: 73–80. https://doi.org/10.1023/A:1021009031717

Gomiero LM, Braga FMDS. 2005. The condition factor of fishes from two river basins in São Paulo state, Southeast of Brazil. *Acta Scientiarum - Biological Sciences*. 27(1): 73–78.

Guarneri I. 2014. A morphometric and genetic comparison of *Sinanodonta woodiana* (Lea, 1834) populations: does shape really matter? *Aquatic Invasions*. 9(2): 183–194. https://doi.org/10.3391/ai.2014.9.2.07

Kingdom T, Azagba S. 201). Age and growth of the freshwater clam *Galatea paradoxa* (Born 1778) from Apoi Creek, Niger Delta, Nigeria. *Archiva Zootechnica*. 20(2): 105–115.

Krampah E, Yankson K, Blay J. 2016. Aspects of reproduction of the brown mussel *Perna perna* at the Iture rocky beach near Cape Coast, Ghana. *African Journal of Marine Science*. 38(4): 503–512. https://doi.org/10.2989/1814232X.2016.1247751

Królak E, Zdanowski B. 2001. Bioaccumulation of heavy metals by the mussels *Anodonta woodiana* (Lea 1834) and *Dreissena polymorpha* (Pall.) in the heated Koninskie lakes. *Archives of Polish Fisheries*. 9(2): 229–237.

Królak E, Zdanowski B. 2017. Phosphorus and calcium in the mussels *Sinanodonta woodiana* (Lea) and *Dreissena polymorpha* (Pall.) in the Konin lakes. *Archives of Polish Fisheries*. 15(4): 287–294.

Li Y, Yang H, Liu N, Luo J, Wang Q, Wang L. 2015. Cadmium accumulation and metallothionein biosynthesis in cadmium-treated freshwater mussel *Anodonta woodiana*. *PLOS ONE*. 10(2): e0117037. https://doi.org/10.1371/journal.pone.0117037

Lim L-S, Ebi I, Liew K-S, Yap T-K, Shi C-K, Tan N-H. 2020. Length-weight relationship and relative condition factor of pearl oyster, *Pinctada fucata martensii*, cultured in the Tieshangang Bay of the Beibu Gulf, Guangxi province, China. *Borneo Journal of Marine Science and Aquaculture*. 44(1): 24–27. https://doi.org/10.51200/bjomsa.v4i1.2048

Liu H, Yang J, Gan J. 2010. Trace element accumulation in bivalve mussels *Anodonta woodiana* from Taihu Lake, China. *Archives of Environmental Contamination and Toxicology*. 59(4): 593–601. https://doi.org/10.1007/s00244-010-9521-6

Liu J, Gu B, Bian J, Hu S, Cheng X, Ke Q, Yan H. 2008. Antitumor activities of liposome-incorporated aqueous extracts of *Anodonta woodiana* (Lea, 1834). *European Food Research and Technology*. 227(3): 919–924. https://doi.org/10.1007/s00217-007-0806-6

Liu Y, Hao A, Iseri Y, Kuba T, Zhang Z. 2014. A comparison of the mussel *Anodonta woodiana*'s acute physiological responses to different algae diets. *Journal of Clean Energy Technologies*. 2(2): 126–131. https://doi.org/10.7763/JOCET.2014.V2.106

Micklem J, Griffiths C, Ntuli N, Mwale M. 2016. The invasive Asian green mussel *Perna viridis* in South Africa: all that is green is not viridis. *African Journal of Marine Science*. 38(2): 207–215. https://doi.org/10.2989/1814232X.2016.1180323

Moëzzi F, Poorbagher H, Ghadermazi A, Parvizi F, Benam S. 2017. Variation in the shell form of the swan mussel, *Anodonta cygnea* (Linea, 1876) in response to water current. *International Journal of Aquatic Biology*. 5(4): 275–281. https://doi.org/10.22034/ijab.v5i4.296

Mondol MR, Nasrin F, Nahar DA. 2016. Length-weight relationships, condition index and sex ratio of mussel *Lamellidens corrianus* (Lea, 1834) in a freshwater lake, Northwest Bangladesh. *Croatian Journal of Fisheries*. 74(4): 172–178. https://doi.org/10.1515/cjf-2016-0025

Nakaoka M. 1992. Spatial and seasonal variation in growth rate and secondary production of *Yoldia notabilis* in Otsuchi Bay, Japan, with reference to the influence of food supply from the water column. *Marine Ecology Progress Series*. 88: 215–223.

Ngor PB, Sor R, Prak LH, So N, Hogan ZS, Lek S. 2018. Mollusc fisheries and length–weight relationship in Tonle Sap flood pulse system, Cambodia. *Annales de Limnologie - International Journal of Limnology*. 54(34): 1–10. https://doi.org/10.1051/limn/2018026

Obirikoran KA, Adjei-Boat D, Madkour HA, Amisah S, Otchere FA. 2013. Length-weight relationship of the freshwater clam, *Galatea paradoxa* (Born 1778) from the Volta Estuary, Ghana. *Pakistan Journal of Biological Sciences*. 16(4): 185–189. https://doi.org/10.3923/pjbs.2013.185.189

Palmer MW. 1990. The estimation of species richness by extrapolation. *Ecology*. 71(3): 1195–1198. https://doi.org/10.2307/1937387

Purnama MF, Haslianti H, Salwiyah S, Admaja AK. 2019. Potensi sumberdaya kijing (*Anodonta woodiana*) di SUB DAS Anak Sungai Lahombuti Kabupaten Konawe - Sulawesi Tenggara. *Saintek Perikanan : Indonesian Journal of Fisheries Science and Technology*. 5(1): 66–72. https://doi.org/10.14710/ijfst.15.1.66-72

Rahim AA, Idris MH, Kamal AHM, Wong SK, Arshad A. 2012. Analysis of condition index in *Polymesoda expansa* (Mousson 1849). *Pakistan Journal of Biological Sciences*. 15(13): 629–634. https://doi.org/10.3923/pjbs.2012.629.634

Raley M, Bogan A, Bowers-Altman J. 2011. The first confirmed record of the Chinese Pond Mussel (*Sinanodonta woodiana*) (Bivalvia: Unionidae) in the United States. *The Nautilus*. 125(1): 41–43.

Ramesha MM, Sophia S. 2015. Morphometry, length-weight relationships and condition index of *Parreysia favidens* (Benson, 1862) (Bivalvia: Unionidae) from river Seeta in the Western Ghats, India. *Indian Journal of Fisheries*. 62(1): 18–24.

Ramesha MM, Thippeswamy S. 2009. Allometry and condition index in the freshwater bivalve *Parreysia corrugata* (Muller) from river Kempuhole, India. *Asian Fisheries Science*. 22(1): 203–214. https://doi.org/10.33997/j.afs.2009.22.1.019

Reichard M, Vrtílek M, Douda K, Smith C. 2012. An invasive species reverses the roles in a host–parasite relationship between bitterling fish and unionid mussels. *Biology Letters*. 8(4): 601–604. https://doi.org/10.1098/rsbl.2011.1234

Rizal S. 2010. *The Utilization of Brachiswaterpond for Experimental Test for Mud Clams Culture* Polymesoda erosa *(Solander, 1786) in Mahakam delta East Kalimantan Province* [Thesis]. Semarang: Diponegoro University.

Rueda M, Urban H-J. 1998. Population dynamics and fishery of the fresh-water clam *Polymesoda solida* (Corbiculidae) in Cienaga Poza Verde, Salamanca Island, Colombian Caribbean. *Fisheries Research*. 39(1): 75–86. https://doi.org/10.1016/S0165-7836(98)00168-4

Seed R. 1968. Factors influencing shell shape in the mussel *Mytilus Edulis*. *Journal of the Marine Biological Association of the United Kingdom*. 48(3): 561–584. https://doi.org/10.1017/S0025315400019159

Sturges HA. 1926. The choice of a class interval. *Journal of the American Statistical Association*. 21(153): 65–66. https://doi.org/10.1080/01621459.1926.10502161

Tampa AI, Lumenta C, Kalesaran OJ. 2014. Morfometrik kijing Taiwan (*Anodonta woodiana*) di beberapa lokasi di Kabupaten Minahasa dan Minahasa Utara. *JURNAL ILMIAH PLATAX*. 2(2): 48. https://doi.org/10.35800/jip.2.2.2014.7148

Taula K, Bahtiar, Purnama MF, Findra MN. 2022. Preferensi habitat kerang lentera (*Lingula unguis*) di Perairan Nambo, Kota Kendari, Sulawesi Tenggara. *Habitus Aquatica*. 3(2): 51–67. https://doi.org/10.29244/HAJ.3.2.51

Thippeswamy S, Malathi S, Anupama NM. 2014. Allometry and condition index in the freshwater bivalve *Parreysia favidens* (Benson, 1862) from river Bhadra, India. *Indian Journal of Fisheries*. 61(4): 47–53.

Thorarinsdottir GG, Johannesson G. 1996. Shell length-meat relationships of ocean quahog, *Arctica islandica* (Linnaeus, 1767), from Icelandic waters. *Journal of Shellfish Research*. 15(3): 729–733.

Trisyani N, Herawati EY, Widodo MS, Setyphadi D. 2016. The length-weight correlation and population dynamics of razor clams (*Solen regularis*) in Surabaya east coast, Indonesia. *Biodiversitas Journal of Biological Diversity*. 17(2): 808–813. https://doi.org/10.13057/biodiv/d170258

Türker D, Zengin K, Tünay ÖK. 2019. Length-weigth relationships for nine chondrichthyes fish species from Edremit Bay (North Aegean Sea). *Turkish Journal of Fisheries and Aquatic Sciences*. 19(1): 71–79. https://doi.org/10.4194/1303-2712-v19_1_08

Uthaiwan K, Noparatnaraporn N, Machado J. 2001. Culture of glochidia of the freshwater pearl mussel *Hyriopsis myersiana* (Lea, 1856) in artificial media. *Aquaculture*. 195(1–2): 61–69. https://doi.org/10.1016/S0044-8486(00)00541-X

Van Hassel JH, Farris J. 2006. A review of the use of unionid mussels as biological indicators of ecosystem health. In *Freshwater Bivalve Ecotoxicology* (pp. 19–49). CRC Press. https://doi.org/10.1201/9781420042856.ch2

Vaughn CC. 2018. Ecosystem services provided by freshwater mussels. *Hydrobiologia*. 810(1): 15–27. https://doi.org/10.1007/s10750-017-3139-x

Watters GT. 1997. A synthesis and review of the expanding range of the Asian freshwater mussel *Anodonta woodiana* (Lea, 1834) (Bivalvia: Unionidae). *The Veliger*. 40(2): 152–156.

Yancheva V, Mollov I, Velcheva I, Georgieva E, Stoyanova S. 2016. Haevy metal effects on the lysosomal membrane stability and respiratory rate in Chinese Pond Mussel (*Sinanodonta woodiana*) under ex situ exposure: preliminary data. *Biharean Biologist*. 10(1): 55–57.

Yang J, Harino H, Liu H, Miyazaki N. 2008. Monitoring the organotin contamination in the Taihu Lake of China by bivalve mussel *Anodonta woodiana*. *Bulletin of Environmental Contamination and Toxicology*. 81(2): 164–168. https://doi.org/10.1007/s00128-008-9464-z

Zhang X, Liu Z, Jeppesen E, Taylor WD. 2014. Effects of deposit-feeding tubificid worms and filter-feeding bivalves on benthic-pelagic coupling: Implications for the restoration of eutrophic shallow lakes. *Water Research*.50: 135–146. https://doi.org/10.1016/j.watres.2013.12.003