Article

Bayesian correlational analysis of conchological features and physicochemical parameters of the golden apple snail (*Pomacea canaliculata* [Lamarck, 1822]) in rice fields of Davao City, Mindanao, Philippines

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Abstract
This study investigates the correlations between various physicochemical parameters and the shell characteristics of *Pomacea canaliculata*, an invasive species, in selected rice fields of Davao City (Buhangin, Tugbok, and Calinan). Specimens were collected through handpicking, with a total of 30 individuals randomly selected from each site. The lower size limit for collection was set at 3.5 cm to exclude juveniles. The analysis revealed strong, and in some cases perfect, correlations between environmental variables and shell morphometry, with Pearson's r consistently showing robust results, supported by anecdotal evidence from Bayes factors. Perfect correlations, indicated by Kendall's Tau-b values, were associated with infinite Bayes factors, further strengthening the observed relationships. These findings emphasize the significant impact of water quality on shell morphometry, suggesting important ecological implications for habitat suitability and species adaptation. Given the invasive nature of *Pomacea canaliculata*, these results provide insights into its adaptation strategies in novel environments, which may inform management efforts to control its spread.

Keywords Bayesian correlation analysis; golden apple snails; physicochemical parameters; rice fields; conchological features.

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1 Introduction

Aquatic invertebrates that populate the soil-floodwater ecosystem of wetland rice fields are considered significant as nutrient recyclers, rice pests, biological control agents, food items, and vectors of human and animal diseases. One of the most common and serious type of invasive organisms is the golden apple snail (*Pomacea canaliculata* [Lamarck, 1822]). The voracious herbivore can devastate rice seedlings, resulting in rice production losses of up to 40% (Bambaradeniya and Amerasinghe, 2003). Golden apple snails do, however, have several well-known advantages. The snail's high protein content makes it a suitable addition to the rural poor's low-protein diet (Food and Agriculture Organization [FAO], 1998). Moreover, local farmers in Southeast Asia used this invasive snail to control weeds in rice fields (Türke et al., 2012).

Macroinvertebrates are frequently used as markers of various environmental conditions. They are reliable indicators because they spend most of their lives in water, are easy to gather, and have different levels of pollution tolerance (Ueno, 2013). *P. canaliculata* is considered ecologically important, persistent, and possesses biomonitor characteristics: (a) they are large enough to provide enough material for analyses, (b) they are easy to handle, collect, and culture, (c) they live long, (d) they are abundant, (e) they are sedentary, (f) they can survive for long periods without food, and (g) they can be found in almost any freshwater ecosystem in many countries (Peña et al., 2017). Knowing all these necessitate a thorough investigation for ecological management and its potential as a biomarker.

Plant growth, crop nutrition management, and soil and water management all benefit from the physicochemical examination of soil and water in agriculture. To properly evaluate and manage deficiencies and improve rice production, physicochemical conditions are taken into account when implementing organic cultivation practices (Harun et al., 2020). In this context, the study on the correlation between physicochemical parameters and shell morphology of golden apple snails (*Pomacea canaliculata*) in selected rice fields of Davao City aims to generate valuable knowledge for landowners and farmers regarding the potential of these organisms as bioindicators of various environmental parameters. Such bioindicators, based on shell morphology, may offer practical insights into soil and water quality, thereby assisting farmers in the informed management of nutrient input during cultivation. This research aligns with the priorities of the Harmonized National Research and Development Agenda–Agriculture, Aquatic and Natural Resources (HNRDA-AANR) sector, which emphasizes the importance of physiological and ecological studies of aquatic species (Department of Science and Technology [DOST], 2022). Furthermore, it supports the objectives outlined in the National Invasive Species Strategy and Action Plan 2020–2030 of the Philippines, which underscores the necessity of basic and applied research on invasive alien species, including studies on their taxonomy, biology, ecology, invasion pathways, and associated risks, to inform policy development and effective management strategies (Department of Environment and Natural Resources–Biodiversity Management Bureau [DENR-BMB], 2020).

The general objective of this research is to study the conchological features of golden apple snails (*P. canaliculata*) in selected rice fields of Davao City. Specifically, the study: (1) determined the physicochemical parameters (depth, temperature, pH, salinity, dissolved oxygen (DO), total dissolved solids (TDS), total hardness, dissolved copper and nitrate concentration) of selected rice paddies of Davao City; (2) determined shell morphometric data (shell length, shell width, length of the aperture, width of the aperture, number of bands, and number of whorls) of collected *P. canaliculata*; and (3) determined statistical correlation between physicochemical parameters of selected rice paddies and shell morphology of collected samples.

2 Study Area and Methodology

2.1 Study site

Prior to the conduct of the study, all necessary communications, legal procedures, and institutional requirements were fulfilled. Formal coordination with the Department of Agriculture–Regional Office XI and the City Agriculturist's Office of Davao was undertaken to obtain permission and logistical support for the research. Additionally, the agriculturist or agriculture officer assigned to each district was contacted, and a formal letter of intent was sent to inform them of the research objectives and procedures. The respective barangay offices of each study site were also approached, and a signed letter of intent from the researcher and research adviser was issued to the individual rice field owners. The schedule, sampling methodology, and overall purpose of the study were clearly explained to the landowners to ensure transparency and informed consent.

The study was conducted in selected rice fields of Davao City, geographically located in the southeastern part of Mindanao at approximately 7.1907° N and 125.4553° E. Davao City encompasses a total land area of 244,400 hectares, with 1,415.24 hectares of rice fields distributed across six districts: Buhangin, Paquibato, Tugbok, Calinan, Baguio, and Marilog. Fig. 1 illustrates the rice field distribution within each district. Among these, Calinan district contained the largest irrigated rice field area, totaling 392.22 hectares, which represented approximately 2% of its total land area. In contrast, Marilog district had the most extensive actual physical rice field area, measuring 599.75 hectares, accounting for about 42.4% of the city's total rice field area.

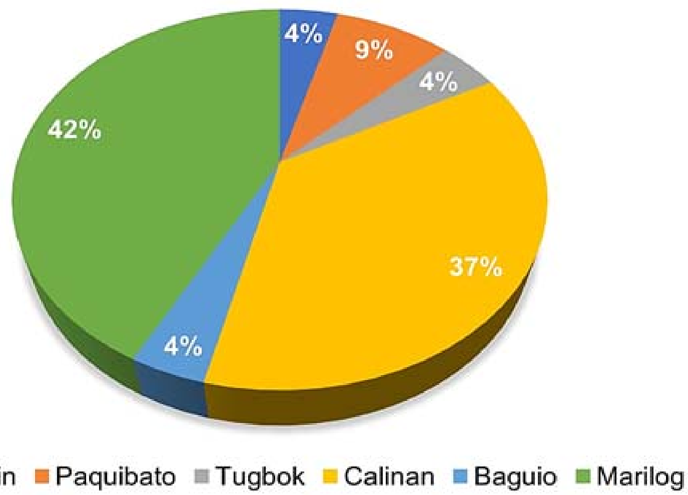

Fig. 1 Distribution of rice field areas in Davao City.

The study was carried out in three agricultural districts (Buhangin, Tugbok, and Calinan) that were exclusively cultivated with rice. The predominant rice varieties observed at the study sites included NSIC RC 214 (TUBIGAN 16), NSIC RC 224 (TUBIGAN 19), NSIC RC 238 (TUBIGAN 21), NSIC RC 9 (APO), and NSIC RC 11 (CANLAON). Although planting and harvesting schedules varied by district, rice was typically cultivated five times over a two-year period. All study sites were treated with inorganic fertilizers, primarily Ammonium phosphate (16-20-0), Urea (46-0-0), and ATLAS PERFECT GRO (14-14-14). Commonly used pesticides included Lorsban 3E, Decis, Dithane M-45, and Malathion. The soil conditions were characterized as warm, muddy, or submerged in freshwater, all of which are conducive to rice growth. The area coverage of each sampling site was recorded using a Global Positioning System (GPS) receiver and subsequently plotted using QGIS software (Fig. 2).

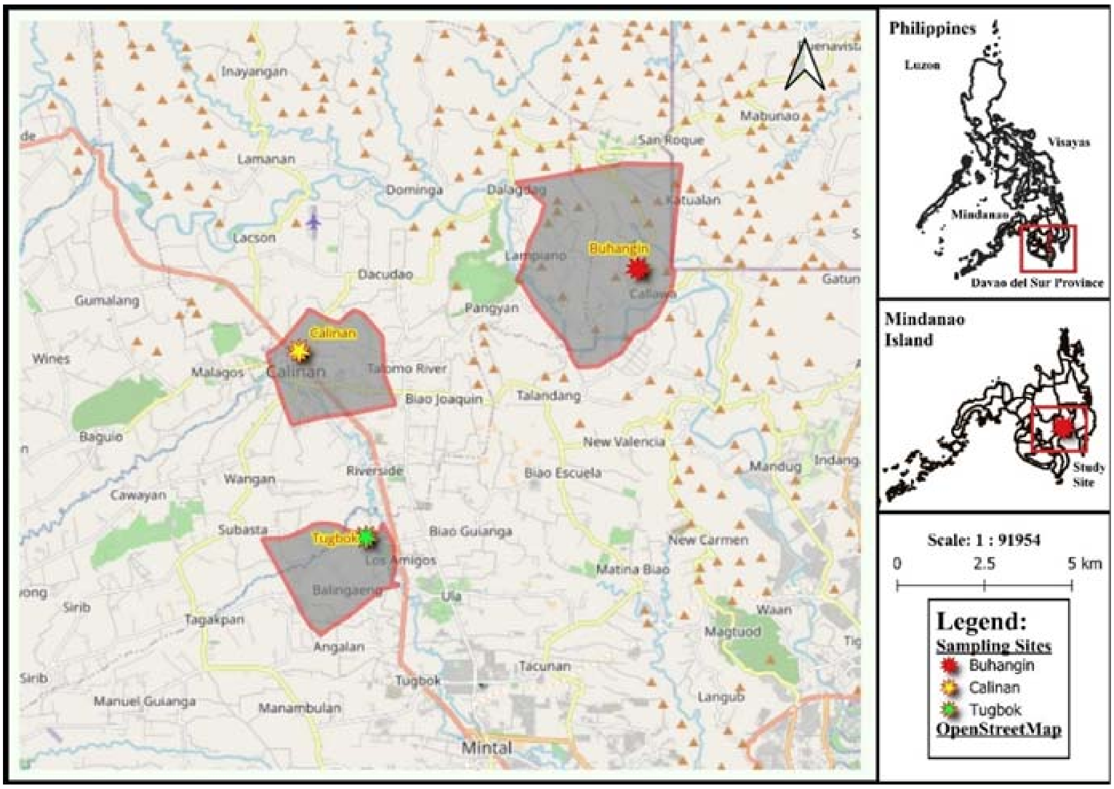

Fig. 2 Sampling sites at Davao City.

2.2 Data collection

2.2.1 The sampling was conducted in three districts: Buhangin, Tugbok, and Calinan. Sampling activities took place from March 3 to March 8, 2025. Table 1 presents the geographical coordinates of the three sampling sites, along with the schedules for the collection of physicochemical data, water samples, and biological specimens.

Table 1 Geographical locations and schedule of collection of the five sampling sites.

District	Geographical Location	Schedule of Collection
Buhangin	7°13'00.7"N, 125°32'28.1"E	March 3-4, 2025
Tugbok	7°11'43.5366"N,125°27'11.9088"E	March 5-6, 2025
Calinan	7°8'49.2036"N, 125°28'14.3142"E	March 7-8, 2025

2.2.2 The water was analyzed for selected physicochemical parameters, including depth, temperature, pH, salinity, dissolved oxygen (DO), total dissolved solids (TDS), total hardness, nitrate concentration, and dissolved copper, using standard analytical methods. The procedures employed for each parameter are described below:

2.2.2.1 Water depth was measured on-site using a plastic ruler and a meter stick. Measurements were performed in triplicate, and the mean and range values were recorded.

2.2.2.2 Water temperature was measured in the field using an alcohol thermometer. Three replicate readings were obtained at each sampling point, and the mean and range were documented.

2.2.2.3 The pH of the water samples was measured using a portable pH meter. Measurements were conducted in triplicate, and the results were averaged to obtain representative values.

2.2.2.4 TDS was measured on-site using a TDS meter. Three replicates were taken per site, and both the mean and range were recorded.
2.2.2.5 Salinity was determined using a handheld refractometer. Replicate measurements (n = 3) were obtained at each site and averaged to reflect site-specific salinity conditions.
2.2.2.6 DO levels were assessed using a portable dissolved oxygen meter. Measurements were conducted in triplicate, with the mean and range values recorded.
2.2.2.7 Water samples intended for the analysis of total hardness, nitrate concentration, and dissolved copper were collected in clean, pre-labeled 1-liter plastic bottles. Following collection, the samples were promptly stored under appropriate conditions to preserve their quality and were subsequently transported to Davao Analytical Laboratories, Inc. for analysis. At the laboratory, the concentrations of total hardness, nitrate, and dissolved copper were determined using standardized analytical procedures in accordance with established protocols.
2.2.3 The collection of *Pomacea canaliculata* specimens was carried out using the handpicking method, as described by the West Virginia Department of Environmental Protection (WVDEP, 2018). From each sampling site, a total of 30 individuals were randomly collected, with a minimum shell length of 3.5 cm to exclude juvenile specimens (CABI, 2019). Collected snails were placed in labeled plastic zip-lock bags, and the live weights of individual specimens were recorded. To facilitate soft tissue extraction, the snails were boiled, after which the shells were thoroughly cleaned. The extracted samples were rinsed with tap water, dabbed dry, and preserved in 70% neutralized ethanol to prevent the dissolution of calcium carbonate in the shell structure. Each specimen was properly labeled with its corresponding collection site and date, following the protocol of Rios-Jara et al. (2009). Throughout the collection, handling, and preservation processes, protective gloves were worn to ensure safety and maintain sample integrity. Shell morphometric parameters—including shell length, shell width, aperture length, aperture width, number of color bands, and number of whorls—were measured to the nearest millimeter. A detailed step-by-step procedure of the data collection process is presented in Fig. 3.

Fig. 3 Step-by-step procedure of data collection.

2.3 Analysis of data

To assess the relationships between variables, the collected data were analyzed using Bayesian Correlation Analysis. This method was employed to evaluate both the presence and strength of associations between pairs of variables. Compared to traditional frequentist approaches, the Bayesian framework offers more intuitive interpretations and reduces the risk of misinterpretation often associated with p-values (Nuzzo, 2017; Schisterman et al., 2003; Zhang, 2022). In parallel with frequentist methods, both parametric (Pearson's r) and non-parametric (Kendall's tau-b) correlation coefficients were reported. However, instead of relying on p-values and confidence intervals, the Bayesian approach utilized Bayes factors (BF) and credible intervals to draw inferences about the strength of associations.

Pearson's correlation coefficient (r) was used to quantify the linear relationship between two continuous, normally distributed variables (Zhang and Li, 2015). The coefficient ranges from -1 to 1, with values closer to ±1 indicating stronger relationships: +1 representing a perfect positive correlation, -1 a perfect negative correlation, and 0 indicating no linear association. The absolute value of r reflects the strength of the relationship, with higher values denoting stronger associations (Echem, 2017). In cases where the data were not normally distributed or involved ordinal or non-parametric variables, Kendall's tau-b correlation coefficient (τ_b) was employed. This nonparametric measure assesses the strength and direction of association based on the number of concordant and discordant pairs in the dataset (Eberly College of Science–The Pennsylvania State University, 2024).

Additionally, Bayesian Correlation Analysis was used to determine the likelihood of the data under two competing hypotheses: the null hypothesis (H0), which posits no association between variables, and the alternative hypothesis (H0), which assumes the presence of a relationship. Bayes' theorem was applied to update the prior beliefs and compute the posterior probabilities of each hypothesis given the observed data. All statistical analyses were performed using Jeffreys' Amazing Statistics Program (JASP) software (Nuzzo, 2017; Schisterman et al., 2003).

3 Results and Discussion

3.1 Shell morphometrics of *Pomacea canaliculata*

There were 90 golden apple snails collected from the three study sites. Each individual was identified morphologically using peer-reviewed journal articles (Cowie, 2005; Hayes et al., 2012). Fig. 4 shows the representative shells of *P. canaliculata* collected from the three study sites.

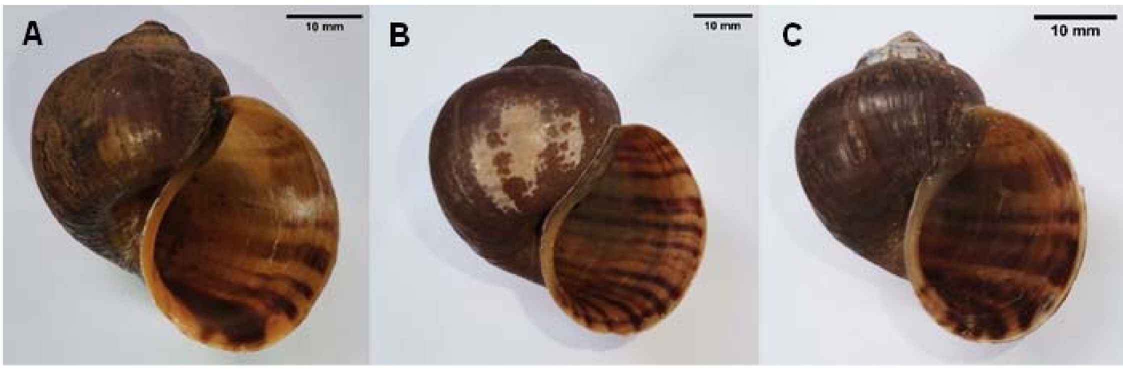

Fig. 4 Apertural view of *Pomacea canaliculata* shells collected from the three study sites: (A) Buhangin; (B) Tugbok; (C) Calinan.

The shell length and width data reveal notable differences between the districts, with Buhangin displaying the largest average measurements in both parameters. The average shell length in Buhangin is 35.74 mm, followed closely by Tugbok at 35.29 mm. In contrast, Calinan exhibits a significantly smaller average shell length of 31.55 mm. Similarly, Buhangin has the largest average shell width at 31.93 mm, while Tugbok and Calinan show smaller values, 31.07 mm and 27.65 mm, respectively.

The aperture width in Buhangin is 17.7 mm, which is slightly smaller than Tugbok's aperture width of 18.68 mm. Calinan, however, has a smaller aperture width of 16.33 mm. Similarly, aperture length in Buhangin is recorded at 25.62 mm, the longest among the three districts, followed by Tugbok at 24.70 mm, with Calinan again having the smallest aperture length at 21.66 mm.

The average number of bands in the shells from Buhangin is 17.77, which is slightly higher than the 16.47 bands observed in Tugbok. Interestingly, Calinan shows the highest average number of bands at 17.80, suggesting that the population from Calinan may exhibit a higher degree of banding complexity. This variation in the number of bands could reflect genetic differentiation or the influence of local environmental factors on the shell's formation (Galan, 2015). Table 2 shows the shell morphometric measurements of *P. canaliculata* collected from the three sampling sites.

Table 2 Shell morphometrics of *Pomacea canaliculata* from the three study sites.

	Shell length (mm)	Shell width (mm)	Aperture width (mm)	Aperture length (mm)	Number of bands	Number of whorls
Buhangin	35.74	31.93	17.70	25.62	17.77	4.30
Tugbok	35.29	31.07	18.68	24.70	16.47	4.53
Calinan	31.55	27.65	16.33	21.66	17.80	4.18

3.2 Physicochemical parameters

The physicochemical parameters of water were measured using analytical methods. A total of two 1-liter samples were collected for each study site. During the conduct of the study, the weather in Buhangin and Tugbok was sunny, while Calinan experienced cloudy or overcast conditions. The depth of the water in the three rice fields shows slight variation, with Calinan recording the deepest average water depth at 6.73 cm, followed by Tugbok at 5.88 cm, and Buhangin at 5.61 cm. The average temperature in Tugbok is the highest at 27.0˚C, followed by Buhangin at 26.58˚C, and Calinan at 26.15˚C.

The pH levels of the water in the three districts show a clear gradient, with Calinan exhibiting the highest average pH of 7.36, indicating a more neutral to slightly basic condition. In contrast, both Buhangin (6.83) and Tugbok (6.84) display slightly acidic conditions, with pH values below 7. The districts of Buhangin and Tugbok measured similar salinity values of 1 ppt. Calinan, however, records a salinity of 0 ppt. Buhangin has the highest average dissolved oxygen concentration at 6.87 mg/L, followed by Tugbok at 6.14 mg/L, and Calinan with the lowest value of 5.26 mg/L. The differences in DO levels can be attributed to factors such as water temperature, organic matter content, and the degree of water mixing (U.S. Environmental Protection Agency, 2024). Higher temperatures, as seen in Tugbok, may lead to lower oxygen solubility, which could partially explain the reduced DO levels compared to Buhangin. The lower DO in Calinan could be indicative of lower water quality or higher organic decomposition rates, possibly due to nutrient loading or restricted water circulation in the area.

Total Dissolved Solids (TDS) represents the concentration of dissolved substances in water, including salts, minerals, and organic matter (Woodard, 2024). Buhangin and Tugbok both show relatively high TDS concentrations at 224 ppm and 230 ppm, respectively, compared to Calinan, which has a significantly lower value of 39 ppm. The higher TDS concentrations in Buhangin and Tugbok could reflect the presence of dissolved salts and minerals, potentially linked to the salinity values observed in these areas. Total hardness, which is primarily determined by the presence of calcium and magnesium ions, varies across the districts.

Tugbok has the highest average total hardness at 84.1 mg $CaCO_3$/L, followed by Buhangin at 61.6 mg $CaCO_3$/L, and Calinan with the lowest at 47.3 mg $CaCO_3$/L.

The nitrate concentrations across the three districts show some variation, with Calinan exhibiting the highest average concentration at 1.8 mg/L, followed by Buhangin at 0.66 mg/L, and Tugbok at 0.5 mg/L. Dissolved copper concentrations in the water were relatively low across all districts, with Buhangin having 0.015 mg/L, Tugbok at 0.013 mg/L, and Calinan at 0.018 mg/L. These values are below the threshold known to pose acute toxicity risks to most aquatic life (Department of Environment and Natural Resources [DENR], 2016). The slight variations in copper concentrations across the districts may reflect local pollution sources, such as industrial activities or the use of copper-containing pesticides (U.S. Environmental Protection Agency, 2025). Table 3 shows the measured physicochemical parameters of each study site.

Table 3 Physicochemical parameters of each study site

	Depth (cm)	Temperature (°C)	pH	Salinity (ppt)	Dissolved Oxygen (mg/L)	Total Dissolved Solids (ppm)	Total hardness (mg $CaCO_3$/L)	Nitrate concentration (mg/L)	Copper as Dissolved Copper (mg/L)
Buhangin	5.58	26.67	6.83	1	6.88	224	61.6	0.66	0.015
Tugbok	5.75	26.33	6.84	1	6.12	230	84.1	0.50	0.011
Calinan	6.75	26.00	7.36	0	5.31	39	47.3	1.80	0.018
Recommended values (DAO 2016-08)		25–31	6.5–9.0		5				0.02

3.3 Bayesian correlation analysis

In Bayesian correlation analysis, two models are compared: the null hypothesis (H_0) that there is no correlation between the two variables, i.e., $\rho = 0$, and the alternative hypothesis (H_1) that there is an association between the two variables, or $\rho \neq 0$. Bayesian inferencing tests how the observed data updates the prior distribution with the posterior distribution. The classification scheme for analyzing Bayes factors proposed by Lee and Wagenmakers in 2003 was used in this study (Lee & Wagenmakers, 2005). This classification scheme, which has been adopted in JASP, generates descriptive labels for interpreting a range of Bayes factors. Table 4 shows the interpretation scheme of the Bayes factor.

Table 4 Interpretation of the Bayes factor (Jeffreys, 1961, as cited in Quintana and Williams, 2018)

Bayes factors (BF_{10})			**Interpretation**
	>	100	Decisive evidence for H_1
30	–	100	Very strong evidence for H_1
10	–	30	Strong evidence for H_1
3	–	10	Substantial evidence for H_1
1	–	3	Anecdotal evidence for H_1
	1		No evidence
1/3	–	1	Anecdotal evidence for H_0
1/10	–	1/3	Substantial evidence for H_0
1/30	–	1/10	Strong evidence for H_0
1/100	–	1/30	Very strong evidence for H_0
	<	1/100	Decisive evidence for H_0

Descriptive analysis was conducted to assess the normality of the data and identify potential outliers. The data that met the assumption of normality were analyzed using Pearson’s correlation coefficient (r), and the corresponding Pearson’s r values are reported. For data that did not meet the assumption of normality, Kendall's tau-b (τb) was employed as an alternative, and the resulting τb values are provided. Table 5 shows the Bayesian correlation matrix of shell morphometric data and physicochemical parameters.

The analysis of the relationships between water physicochemical parameters and shell characteristics revealed strong correlations, with both Pearson's r and Kendall's Tau-b values providing meaningful insights. Specifically, the correlation between water depth and shell length showed a Pearson's r value of -0.991, indicating a very strong negative relationship, with a Bayes factor (BF_{10}) of 1.639 offering anecdotal evidence in support of this finding. Similarly, the Pearson's r values for water depth and shell width (-0.999) and water depth and aperture length (-1.000) also indicated nearly perfect negative correlations, both supported by Bayes factors (BF_{10}) of 1.505, also suggesting anecdotal evidence supporting these inverse relationships.

Regarding other parameters, dissolved oxygen showed a very strong positive correlation with aperture length (Pearson's r = 0.970, BF_{10} = 1.419), while total hardness exhibited a similarly strong positive correlation with aperture width (Pearson's r = 0.975, BF_{10} = 1.459). These findings were further confirmed by total dissolved solids, which demonstrated near-perfect positive correlations with shell length (Pearson's r = 0.992, BF_{10} = 1.661), shell width (Pearson's r = 0.976, BF_{10} = 1.468), and aperture length (Pearson's r = 0.969, BF_{10} = 1.409), all of which were supported by anecdotal evidence from the corresponding Bayes factors. Nitrate concentration and shell length exhibited a strong negative correlation (Pearson's r = -0.978, BF_{10} = 1.482), indicating that higher nitrate concentrations tend to be associated with smaller shell lengths.

In data where normality assumptions were violated, Kendall's Tau-b correlations revealed perfect relationships. For example, temperature and the number of bands showed a perfect negative correlation (τb = -1.000), as did pH with shell length, shell width, and aperture length, all demonstrating perfect negative associations (τb = -1.000). Similarly, total hardness and number of bands (τb = -1.000), total dissolved solids and number of bands (τb = -1.000), nitrate concentration and number of bands (τb = -1.000), and dissolved copper and number of bands (τb = -1.000) also exhibited perfect negative correlations. These relationships were strongly supported by Bayes factors ($BF_{10} = \infty$), indicating overwhelming evidence for the existence of these correlations.

The toxic effect of copper on aquatic invertebrates has been well documented. Although the Bayes factors indicate only anecdotal support for the relationship between shell morphometrics and dissolved copper concentration, the biological relevance is supported by experimental evidence. In the study conducted by Peña et al. (2017), exposure of *P. canaliculata* to sublethal concentrations of copper (67.5 μg/L) over a seven-day period resulted in pronounced histopathological alterations in several critical organs. These included hydropic degeneration and disintegration of renal tissues, hyperplasia of K corpuscles in the digestive gland, epithelial flattening and muscular disarray in the foot, and significant morphological changes in the gills, such as filament dilation and folding. These structural damages indicate systemic physiological stress and impaired organ function.

Such toxic effects likely interfere with the snail's ability to carry out essential metabolic processes, including nutrient assimilation, ion regulation, and calcium homeostasis, which are key functions involved in shell formation and maintenance. Damage to the digestive gland may reduce nutrient uptake efficiency, while renal impairment could affect excretion and osmoregulation. Moreover, gill damage may compromise oxygen exchange, further reducing metabolic efficiency. Together, these pathologies would likely result in reduced growth performance and impaired biomineralization, manifesting as lower shell morphometric values.

Galan et al. (2015) found no significant correlation between the physicochemical parameters and shell morphometry of golden apple snails in selected aquatic habitats within the Central Mindanao University campus and surrounding areas in Bukidnon, Philippines, with the exception of the relationship between water depth and both the number of bands and average band width. However, determining whether the lack of significance is attributable to data insensitivity or an absence of a relationship between the two variables is challenging when using p-values as the sole measure of statistical significance (Quintana and Williams, 2018). In summary, the results suggest that water physicochemical parameters strongly influence shell morphometry, with varying degrees of correlation, all supported by anecdotal or overwhelming evidence from the Bayes factors, underscoring the ecological relevance of these findings.

Table 5 Bayesian correlation matrix of shell morphometric data and physicochemical parameters

Variable		Depth	Temperature	pH	Salinity	DO	Total hardness	TDS	Nitrate conc.	Dissolved Cu
Shell length	Pearson's r	-0.991	0.817			0.932	0.732	0.992	-0.978	-0.874
	BF_{10}	1.639	0.974			1.227	0.879	1.661	1.482	1.071
	Kendall's tau			-1.000	0.816					
	BF_{10}			∞	1.067					
Shell width	Pearson's r	-0.999	0.760			0.961	0.665	0.976	-0.954	-0.825
	BF_{10}	1.505	0.906			1.364	0.828	1.468	1.323	0.986
	Kendall's tau			-1.000	0.816					
	BF_{10}			∞	1.067					
Aperture length	Pearson's r	-1.000	0.738			0.970	0.641	0.969	-0.944	-0.807
	BF_{10}	1.505	0.885			1.419	0.812	1.409	1.275	0.960
	Kendall's tau			-1.000	0.816					
	BF_{10}			∞	1.067					
Aperture width	Pearson's r	-0.789	0.996[a]			0.623	0.975	0.921	-0.951	-1.000
	BF_{10}	0.939	0.000			0.802	1.459	1.190	1.307	1.505
	Kendall's tau			-0.333	0.816					
	BF_{10}			0.691	1.067					
Number of bands	Pearson's r									
	BF_{10}									
	Kendall's tau	0.333	-1.000	0.333	-0.816	-0.333	-1.000	-1.000	-1.000	1.000
	BF_{10}	0.691	∞	0.691	1.067	0.691	∞	∞	∞	∞
Number of whorls	Pearson's r	-0.593	0.983			0.387	0.999[a]	0.780	-0.831	-0.957
	BF_{10}	0.785	1.531			0.711	0.000	0.928	0.994	1.339
	Kendall's tau			-0.333	0.816					
	BF_{10}			0.691	1.067					

[a] beta A > 0 is not TRUE.

4 Conclusions

The results indicate that numerous physicochemical parameters show strong, and in some instances, perfect correlations with the shell characteristics of *Pomacea canaliculata*, an invasive species. For variables analyzed using Pearson's r, the correlations were consistently robust, with anecdotal support from the Bayes factors. In contrast, the Kendall's Tau-b values, reflecting perfect correlations, were associated with infinite Bayes factors, providing compelling evidence for the observed relationships. These findings underscore the significant impact of water quality parameters on shell morphometry, suggesting important ecological implications for habitat suitability and species adaptation. As *Pomacea canaliculata* is an invasive species, these relationships may also contribute to understanding its adaptation strategies in novel environments, potentially informing management efforts aimed at mitigating its spread.

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