Egyptian Journal of Aquatic Biology & Fisheries
Zoology Department, Faculty of Science,
Ain Shams University, Cairo, Egypt.
ISSN 1110 – 6131
Vol. 29(5): 57 – 70 (2025)
www.ejabf.journals.ekb.eg

# Integrated Evaluation of Productivity Factors in Intensive White Shrimp (*Litopenaeus vannamei*) Aquaculture in Ecuador

**Simon Abelardo Ramos-Mendieta, Diana Vicky Aguilar-Pita, Jaime Marcelo Coello-Viejó and Vanessa Meryanne Briones-Peña***
Universidad Estatal de Milagro (UNEMI), Milagro, Provincia del Guayas, 091050, Ecuador

***Corresponding Author: sramosm2@unemi.edu.ec**

## ARTICLE INFO
**Article History:**
Received: June 10, 2025
Accepted: Aug. 28, 2025
Online: Sep. 4, 2025

**Keywords**:
*Litopenaeus vannamei*,
Intensive aquaculture,
Water source,
Feeding frequency,
Incidence of vibriosis,
Productivity

## ABSTRACT
The Pacific white shrimp (*Litopenaeus vannamei*) is a key species in global aquaculture due to its high economic value and adaptability to intensive farming. In Ecuador, the intensification of shrimp production has created challenges related to environmental control and production efficiency. This study evaluated the influence of environmental and management variables on shrimp productivity across different farming systems. The parameters assessed included farming system, water source, feeding frequency, feed type, pH, dissolved oxygen, ammonia concentration, and vibriosis incidence. Statistical analyses using factorial ANOVA, Spearman's correlation, and principal component analysis (PCA) revealed no significant effects of individual factors; however, a significant three-way interaction was identified among farming system, water source, and feeding frequency ($P$= 0.0251), indicating synergistic effects on productivity. Dissolved oxygen exhibited a strong positive correlation with productivity ($P$= 0.78), while vibriosis incidence showed a moderate negative correlation ($P$= –0.29). PCA further revealed two dominant environmental gradients—health stress and physicochemical quality—associated with distinct farming profiles. These findings suggest that optimizing shrimp production in intensive systems requires integrated monitoring and management strategies that account for interactions among farming practices and environmental conditions.

## INTRODUCTION

Shrimp farming, particularly the intensive culture of *Litopenaeus vannamei*, has become a cornerstone of aquaculture development in tropical regions due to its high global demand, export potential, and adaptability to diverse production systems **(FAO, 2020; Zhao *et al.*, 2020)**. In Ecuador—especially in the province of Guayas—shrimp aquaculture plays a fundamental economic role and has evolved through the adoption of multiple production models and management strategies that aim at maximizing productivity under varied environmental conditions **(Valenzuela *et al.*, 2021; Villarreal & Juarez, 2022)**.

The productivity of intensive shrimp farming systems is shaped by a complex interaction of biophysical and operational factors. Critical determinants include infrastructure design (e.g., earthen ponds, biofloc systems, or cages), water source characteristics, feed management protocols, and pathogen prevalence, particularly infections by *Vibrio* spp. **(Trejo *et al.*, 2021; Jerônimo *et al.*, 2022; Velásquez López *et al.*, 2023)**. These factors affect not only the physiological performance of shrimp but also the ecological balance of farming environments, with implications for both production efficiency and long-term sustainability **(Varela & Choc-Martínez, 2020; Mora-Faubla *et al.*, 2025)**.

Among these factors, feeding practices are particularly decisive for production outcomes **(Valenzuela *et al.*, 2020)**. Innovations such as probiotic-supplemented or fermented feeds have been shown to improve nutrient absorption, modulate gut microbiota, and increase resilience to environmental stressors and pathogenic challenges **(Crab *et al.*, 2007; Prabu *et al.*, 2020)**. Similarly, the quality and origin of water inputs—whether from estuaries, canals, or deep wells—directly influence microbial load and chemical stability, thereby affecting shrimp health and growth **(Walker & Winton, 2010)**.

Despite advances in shrimp aquaculture, there remains a need for integrative approaches that capture the multivariate complexity of farm performance rather than relying solely on univariate analyses. Multivariate statistical tools, such as factorial ANOVA, clustering algorithms, and principal component analysis (PCA), enable the identification of performance patterns and the classification of farms into meaningful typologies, which can inform targeted management interventions **(Guevara *et al.*, 2022; Valenzuela *et al.*, 2023a, c)**.

This study aimed to evaluate how environmental conditions and operational practices influence shrimp productivity in intensive farming systems along the Ecuadorian coast. Furthermore, it seeked to classify farms into homogeneous groups based on shared production profiles using multivariate techniques **(Valenzuela *et al.*, 2023b)**. By combining field data with advanced statistical analysis, this research contributes to a deeper understanding of productivity drivers in shrimp aquaculture and offers practical insights for optimizing farm management and sustainability **(Carvajal-Morales *et al.*, 2024)**.

## MATERIALS AND METHODS

### Study area

This study was conducted in the province of Guayas, on the coast of Ecuador, specifically in four cantons with recognized aquaculture activity. These localities are among the main production areas for white shrimp (*Litopenaeus vannamei*) and have diverse characteristics in terms of farming systems, access to water, technical management, and environmental conditions. Fig. (1) shows the geographical location of these cantons within the national territory, highlighting their strategic location and proximity to estuarine ecosystems that are key to the development of aquaculture.

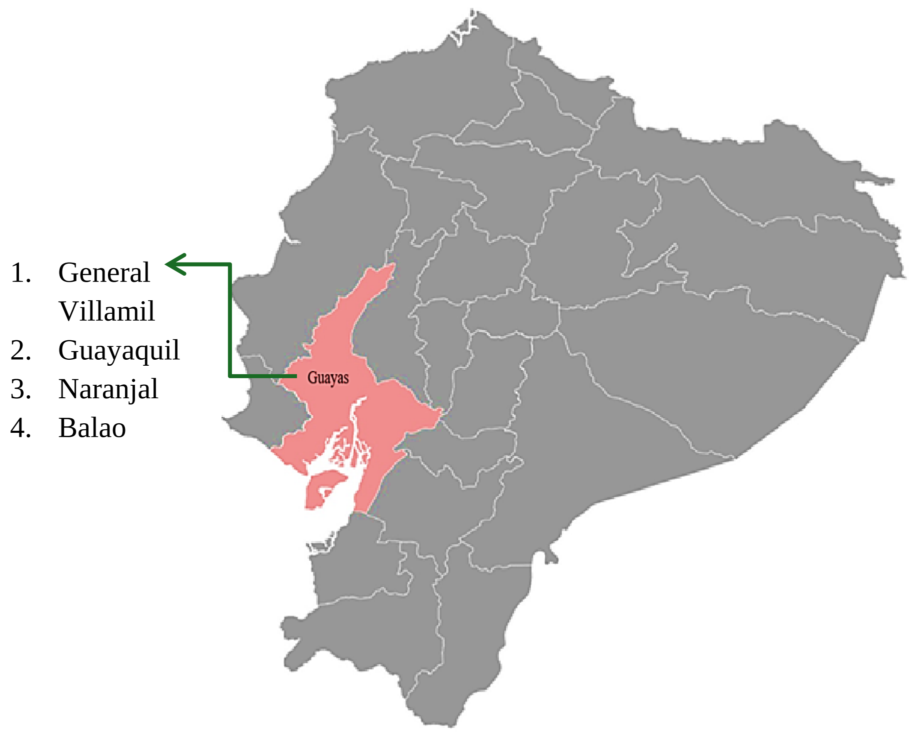


**Fig. 1.** Geographical location of the cantons evaluated in the province of Guayas, Ecuador

### Study design

This study employed a quantitative, observational, cross-sectional design with the objective of characterizing farming conditions and water quality in shrimp farms during the dry season, from June to September 2024. This period is particularly relevant, as it strongly influences key parameters such as salinity and other physicochemical variables of water, which are critical determinants of aquaculture productivity **(Boyd, 2020)**.

A total of 65 farms distributed across four cantons were selected using non-probabilistic intentional sampling, prioritizing active production units that were willing to participate voluntarily. This selection strategy ensured variability in management practices, farming methods, and environmental conditions, which was essential for the subsequent multivariate statistical analyses **(Martinez & Martinez, 2012)**.

**Data collection**

Data were obtained through technical visits to each farm using a structured questionnaire that captured technical and operational variables of the aquaculture system. The information collected included crop type, water source, feeding frequency and type, estimated production yield (kg/ha/cycle), and health indicators, particularly the incidence of bacterial diseases.

In addition, *in situ* measurements of water quality were carried out using properly calibrated portable equipment. Critical parameters such as pH, dissolved oxygen, and ammonium concentration were measured. To reduce the effects of diel variation, all measurements were conducted consistently between 6:00 a.m. and 10:00 a.m. Each farm also provided a representative sample from its main production unit.

Hypotheses

- $H_0$ (null hypothesis): Environmental and management variables (e.g., pH, dissolved oxygen, feeding type, disease incidence) do not significantly explain variation in shrimp productivity ($kg \cdot ha^{-1} \cdot yr^{-1}$).
- $H_1$ (alternative hypothesis): At least one environmental or management variable significantly ($\alpha = 0.05$) influences productivity, either individually or in combination, within a multivariate analytical framework such as linear regression or cluster analysis.

**Evaluated variables**

Table (1) presents the variables considered in the study, along with their type, description, and coding for statistical analyses. These variables encompass productive, environmental, and operational aspects of intensive shrimp farms, including both categorical and continuous factors. Data collected covered geographic location, farming system, water source, feeding regime, and key water quality parameters.

**Table 1.** Description of evaluated variables used in the multivariate analysis

| Variable Name | Type | Description / Levels | Coding |
|---|---|---|---|
| Zone | Categorical | Location by canton (e.g., Balao, Milagro) | 1–7 |
| Sys_Crop | Categorical | Type of culture system | Jaula (1), Estanque (2), Biofloc (3) |
| Wa_Sou | Categorical | Source of water used | Pozo (1), Estero (2), Canal (3) |
| W_Quality | Continuous | Ammonium concentration (ppm) | Numeric (0.3–1.0) |
| pH | Continuous | Water pH value | Numeric |
| Oxygen | Continuous | Dissolved oxygen (mg/L) | Numeric |
| Fee_Fre | Categorical | Frequency of feeding (rations per day) | 1 (1-2), 2 (3-4), 3 (5+) |
| Feed_Type | Categorical | Type of feed used | Balanceado (1), Balanceado+Probiótico (2), Fermentado (3) |
| Vib_Inc | Continuous | Vibriosis incidence (%) | Numeric (0–15%) |
| Productivity | Dependent | Yield per hectare per year (kg $ha^{-1}$ $yr^{-1}$) | Numeric |

**Statistical analysis**

All statistical analyses were performed using R (version 4.3.1). The analytical framework included:

- Descriptive Statistics: Mean, standard deviation, minimum and maximum values were calculated for all continuous variables. Frequency distributions were generated for categorical variables.
- Spearman Correlation: Used to evaluate monotonic relationships between water quality parameters and productivity.
- One-Way ANOVA: Conducted to compare mean productivity across categorical variables (e.g., system type, feed type) **(Valenzuela *et al.*, 2020)**.
- Cluster Analysis: K-means and hierarchical clustering were used to identify typologies among farms based on environmental and management profiles **(Guevara-Viejó *et al.*, 2021; Valenzuela-Cobos *et al.*, 2022)**.

Assumptions of normality and homoscedasticity were assessed using Shapiro-Wilk and Levene's tests. Significance was set at $\alpha = 0.05$.

## RESULTS

### Descriptive characterization of productive and operational variables

The descriptive analysis enabled the characterization of the sampled shrimp farms according to their operational and management variables. Table (2) summarizes the percentage distribution of the main categories. A greater concentration of farms was located in beach areas (30.77%), while the predominant farming system was cages (49.23%), reflecting a preference for technologies adapted to open water bodies. Regarding water sources, rivers (41.54%) were the most frequently used, underscoring the continued reliance on natural ecosystems for aquaculture production. This finding is consistent with international reports describing the common use of riverine and estuarine resources in tropical aquaculture systems **(FAO, 2020)**.

Feeding practices revealed a higher prevalence of frequencies greater than seven rations per day (35.38%), which suggests the adoption of intensive fattening strategies. Probiotic-supplemented feed was the most widely used type (47.69%), highlighting the increasing adoption of technified practices aimed at enhancing feed efficiency and crop health. This trend aligns with previous studies demonstrating the beneficial effects of probiotics on growth performance and disease resistance in aquaculture species **(Lara *et al.*, 2003)**.

**Table 2.** Percentage distribution of production variables

| Variable | Description | Frequency | Proportion |
|---|---|---|---|
| **Zone** | Balao | 17 | 26,15% |
| | Guayaquil | 14 | 21,54% |
| | Naranjal | 14 | 21,54% |
| | Playas | 20 | 30,77% |
| **Culture System** | Biofloc | 16 | 24,62% |
| | Pond | 17 | 26,15% |
| | Cage | 32 | 49,23% |
| **Water Source** | Canal | 20 | 30,77% |
| | Deep Well | 18 | 27,69% |
| | River | 27 | 41,54% |
| **Feeding Frequency** | Up to 3 times | 21 | 32,31% |
| | 4 to 6 times | 21 | 32,31% |
| | More than 7 times | 23 | 35,38% |
| **Feed Type** | Balanced | 17 | 26,15% |
| | Balanced + Probiotic | 31 | 47,69% |
| | Fermented | 17 | 26,15% |

## Relationship between environmental parameters and productivity

The correlation matrix in Fig. (2) shows the degree of association between environmental and health variables with respect to annual productivity per hectare. There is a strong positive correlation between dissolved oxygen and productivity (*P*= 0.78), indicating that higher oxygen values are consistently associated with better yields, especially in semi-intensive and intensive systems. This association is consistent with studies that highlight oxygen as a limiting factor for the growth and survival of *Litopenaeus vannamei* **(Boyd & Tucker, 1998)**.

.

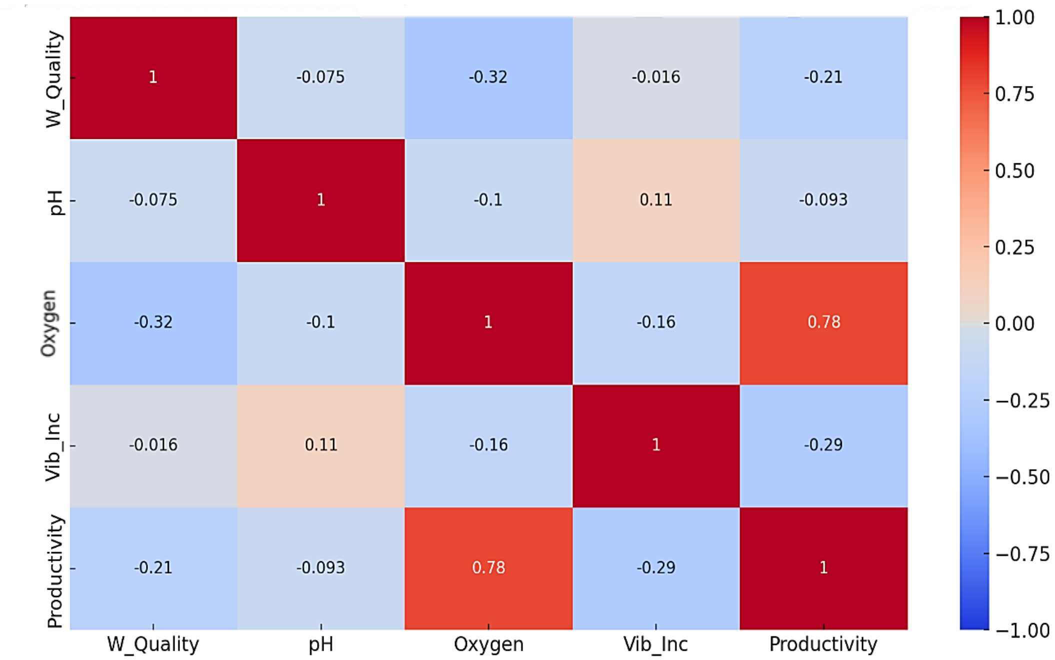


**Fig. 1.** Correlation analysis between environmental factors and annual productivity

In contrast, the variable incidence of *Vibrio* spp. shows a moderate negative correlation (*P*= -0.29), suggesting that an increase in the presence of this pathogenic bacterium is linked to a reduction in yield. Variables such as pH and ammonium concentration (W_Quality) show a weak or insignificant correlation with productivity, implying that their effect may depend on interactions with other factors, such as organic load, temperature, or feed management. These results reinforce the need to adopt a comprehensive management approach, including health control and continuous environmental monitoring **(Sanaye *et al*., 2014; Valenzuela *et al.*, 2019)**.

**Productivity by system and feed (ANOVA)**

The results of the factorial analysis of variance (Table 2) indicated that, individually, none of the main factors (cultivation system, water source, feeding frequency, and type of feed) had statistically significant effects on the annual productivity of intensive *Litopenaeus vannamei* cultivation ($P > 0.05$). However, the water source variable showed a marginal trend toward significance ($F = 3.084$; $P = 0.0669$), suggesting possible differences related to the physicochemical and microbiological quality of the water resource, in line with the findings of **Campanati *et al.* (2022)**, who highlighted the critical role of water in the stability of the environment and the health of the crop.

**Table 3.** Results of the factorial ANOVA on productivity according to management factors.

| Interaction | F-value | *P*-value | Interpretation |
|---|---|---|---|
| Sys_Crop | 0.692 | 0.5118 | Not significant |
| Wa_Sou | 3.084 | 0.0669 | Marginal trend |
| Fee_Fre | 0.014 | 0.9857 | Not significant |
| Feed_Type | 1.175 | 0.3284 | Not significant |
| Sys_Crop × Wa_Sou × Fee_Fre | 3.085 | 0.0251 | **Significant ($P < 0.05$)** |

Fig. (3) illustrates the box plots corresponding to the main effects. Regarding the farming system, the Cage and Biofloc treatments showed slightly higher medians than the Pond system, although with evident overlap between the interquartile ranges, which coincides with their lack of statistical significance. For the water source, a higher median productivity was observed in systems fed with deep well water, while the use of river water was associated with lower yields, which could be explained by higher microbial loads or variability in quality parameters **(Boyd & Tucker, 1998; Arnull *et al.*, 2021)**.

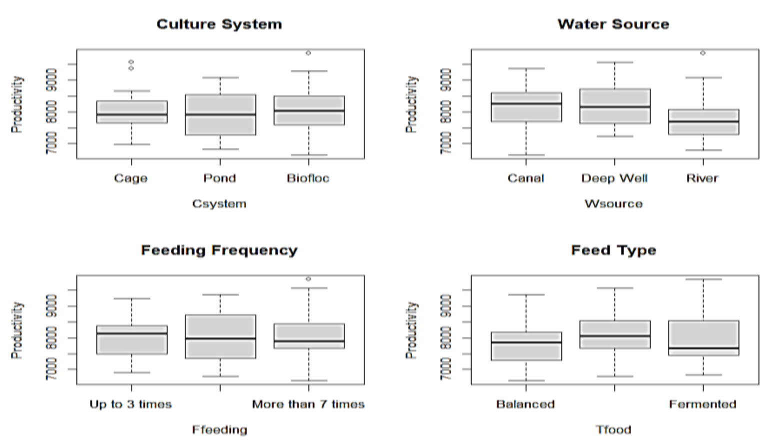


**Fig. 3.** Distribution of productivity according to main management factors

## Principal component analysis (PCA)

Principal component analysis (PCA) was applied to identify multivariate patterns among environmental variables and their relationship with productivity in intensive *Litopenaeus vannamei* farming systems. This technique allowed for a reduction in the dimensionality of the dataset and represented the directions of greatest variance without substantial loss of information **(Jolliffe & Cadima, 2016; Torres-Ordónez *et al.*, 2024)**. The variables included were water source, ammonium concentration, pH, dissolved oxygen, and incidence of vibriosis, all of which were previously standardized. The first two components explained 63.8% of the total variance (PC1: 37.5%, PC2: 26.3%).

**Table 4.** Standardized factor loadings obtained from principal component analysis (PCA) applied to environmental and productivity variables

| Variable | PC1 | PC2 |
|---|---|---|
| W_Quality (amonio) | 0.62 | 0.34 |
| pH | 0.12 | 0.81 |
| Oxygen | -0.28 | 0.72 |
| Vib_Inc | 0.65 | -0.12 |
| Productivity | 0.59 | 0.44 |

The first component (PC1) was mainly related to ammonium concentration, vibriosis, and productivity, while the second (PC2) reflected greater weight in pH and dissolved oxygen, thus defining two gradients: one sanitary-productive and the other physicochemical. The corresponding loads are summarized in Table (4). The biplot showed groupings of farms, where cage systems with river water were associated with higher levels of vibriosis, and biofloc systems with better environmental conditions **(Ringnér, 2008; Valenzuela *et al*., 2023d)**.

## DISCUSSION

The most relevant finding of this study was the detection of a statistically significant triple interaction between farming system, water source, and feeding frequency (F= 3.085; *P*= 0.0251). This result indicates that productive performance in shrimp farming depends not only on isolated factors but also on their synergistic interaction. It provides empirical support for the alternative hypothesis ($H_1$), which posits that environmental and management variables significantly influence productivity, either independently or in combination. These findings are consistent with previous studies emphasizing that performance in high-intensity systems is determined by the integration of management strategies, water quality, and feeding regime **(Wang *et al.*, 2022)**. From a statistical perspective, this third-order interaction reveals non-additive effects, where specific combinations of factors generate differentiated outcomes in productivity.

These multivariate dependencies underscore the complex ecology of *Litopenaeus vannamei* production systems. The marginal effect of water source observed in the ANOVA aligns with the observations of **Felix *et al.* (2020)**, who highlighted how water origin influences microbial dynamics and nutrient load, thereby interacting with feeding practices to alter growth outcomes. Similarly, **Do *et al.* (2025)** demonstrated that nutrient management and culture system design jointly affect productivity in intensive environments. Supporting this, **Wang *et al.* (2022)** used multivariate approaches to show that spatial and operational variables jointly shape yield clusters, reinforcing the need for integrated analytical frameworks.

The strong positive correlation between dissolved oxygen and productivity ($\rho$ = 0.78) highlights the critical role of aeration and water exchange protocols. This finding is in line with **Hasman *et al.* (2023)**, who identified dissolved oxygen as the single most important water quality parameter influencing shrimp survival and growth. Conversely, the moderate negative correlation between vibriosis incidence and productivity ($\rho$= –0.29) corroborates the results of **Prangnell *et al.* (2016)**, who reported that inadequate monitoring of *Vibrio* spp. in limited-exchange systems significantly reduced growth and survival rates.

Finally, the PCA revealed two distinct environmental gradients: a sanitary–productive axis (ammonia, vibriosis, productivity) and a physicochemical axis (pH, dissolved oxygen). These gradients allowed for the classification of farms into groups with divergent risk profiles. Biofloc systems clustered with favorable physicochemical conditions, likely reflecting their superior microbial regulation capacity, whereas cage systems reliant on river water were associated with higher health risks. This pattern is consistent with the findings of **Crab *et al.* (2007)**, who demonstrated that biofloc systems improve water quality and increase resilience under conditions of high stocking density.

## CONCLUSION

Beyond environmental and production factors, the competitiveness of the shrimp sector also depends on producer training and access to quality inputs. Integrating technical training and logistical support programs can promote the adoption of sustainable practices on small and medium-sized farms.

The findings invite exploration of hybrid production models that combine biofloc, renewable energy, and water reuse, contributing not only to production efficiency but also to reducing the environmental footprint and increasing the sector's resilience to climate change.

In addition, the study highlights the need to incorporate digital monitoring tools and artificial intelligence into intensive shrimp aquaculture, as these technologies would enable the anticipation of environmental imbalances and the optimization of management decisions in real time.

## REFERENCES


**Arnull, J.; Wilson, A.; Brayne, K.; Dexter, K.; Donah, A.; Gough, C.; Klückow, T.; Ngwenya, B. and Tudhope, A. (2021)**. Ecological co-benefits from sea cucumber farming: Holothuria scabra increases growth rate of seagrass. *Aquaculture Environment Interactions*, 13, 301-310. https://doi.org/10.3354/aei0040

**Boyd, C. E. (2020)**. *Water Quality: An Introduction*. Springer International Publishing. https://doi.org/10.1007/978-3-030-23335-8

**Boyd, C. E. and Tucker, C. S. (1998)**. *Pond aquaculture water quality management*. Springer.

**Campanati, C.; Willer, D.; Schubert, J. and Aldridge, D. C. (2022)**. Sustainable Intensification of Aquaculture through Nutrient Recycling and Circular Economies: More Fish, Less Waste, Blue Growth. *Reviews in Fisheries Science & Aquaculture*, 30(2), 143-169. https://doi.org/10.1080/23308249.2021.1897520

**Carvajal-Morales, J. M.; León-Plúas, E. E.; Valenzuela-Cobos, J. D. and Guevara-Viejó, F. (2024)**. Educational Design in the Adoption of ICT for Sustainable Digital Learning in Social and Business Sciences: A Structural Equation Model. *Sustainability*, 16(23), 10674. https://doi.org/10.3390/su162310674

**Crab, R.; Avnimelech, Y.; Defoirdt, T.; Bossier, P. and Verstraete, W. (2007)**. Nitrogen removal techniques in aquaculture for a sustainable production. *Aquaculture*, 270(1-4), 1-14. https://doi.org/10.1016/j.aquaculture.2007.05.006

**Do, D. D.; Le, A. H.; Vu, V. V.; Le, D. A. N. and Bui, H. M. (2025)**. Evaluation of water quality and key factors influencing water quality in intensive shrimp farming systems using principal component analysis-fuzzy approach. *Desalination and Water Treatment*, 321, 101002. https://doi.org/10.1016/j.dwt.2025.101002

**FAO. (2020)**. *The State of World Fisheries and Aquaculture 2020*. FAO. https://doi.org/10.4060/ca9229en

**Felix, S.; Samocha, T. and Menaga, M. (2020)**. *Vannamei Shrimp Farming* (1st ed.). CRC Press. https://doi.org/10.1201/9781003083276

**Guevara-Viejó, F.; Valenzuela-Cobos, J. D.; Grijalva-Endara, A.; Vicente-Galindo, P. and Galindo-Villardón, P. (2022)**. Data Mining Techniques: New Method to Identify the Effects of Aquaculture Binder with Sardine on Diets of Juvenile *Litopenaeus vannamei*. *Sustainability*, 14(7), 4203. https://doi.org/10.3390/su14074203

**Guevara-Viejó, F.; Valenzuela-Cobos, J. D.; Vicente-Galindo, P. and Galindo-Villardón, P. (2021)**. Data-Mining Techniques: A New Approach to Identifying the Links among Hybrid Strains of *Pleurotus* with Culture Media. *Journal of Fungi*, 7(10), 882. https://doi.org/10.3390/jof7100882

**Hasman, N. A.; Ahmad, I.; Rusli, J. R.; Marwangi Mohamad Maharum, S.; Thirunavakkarasu, P. and Mansor, Z. (2023)**. An IoT Water Quality Monitoring System for Shrimp Farming in Aquaculture. *2023 International Conference on Engineering Technology and Technopreneurship (ICE2T)*, 177-182. https://doi.org/10.1109/ICE2T58637.2023.10540538

**Jerônimo, G. T.; Da Cruz, M. G.; Bertaglia, E. D. A.; Furtado, W. E. and Martins, M. L. (2022)**. Fish parasites can reflect environmental quality in fish farms. *Reviews in Aquaculture*, 14(3), 1558-1571. https://doi.org/10.1111/raq.12662

**Jolliffe, I. T. and Cadima, J. (2016)**. Principal component analysis: A review and recent developments. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, 374(2065), 20150202. https://doi.org/10.1098/rsta.2015.0202

**Lara-Flores, M.; Olvera-Novoa, M. A.; Guzmán-Méndez, B. E. and López-Madrid, W. (2003)**. Use of the bacteria *Streptococcus faecium* and *Lactobacillus acidophilus*, and the yeast *Saccharomyces cerevisiae* as growth promoters in Nile tilapia (*Oreochromis niloticus*). *Aquaculture*, 216(1-4), 193-201. https://doi.org/10.1016/S0044-8486(02)00277-6

**Martinez-Porchas, M. and Martinez-Cordova, L. R. (2012)**. World Aquaculture: Environmental Impacts and Troubleshooting Alternatives. *The Scientific World Journal*, 2012, 1-9. https://doi.org/10.1100/2012/389623

**Mora-Faubla, G. M.; Delgado-Villafuerte, C. R.; Peñarrieta-Macias, F. F. and Urdanigo-Mendoza, L. C. (2025)**. White shrimp (*Litopenaeus vannamei*) production and its impact on the physicochemical components of water in the Gulf of Guayaquil, Ecuador. *MQRInvestigar*, 9(2), e639. https://doi.org/10.56048/MQR20225.9.2.2025.e639

**Prabu, E.; Felix, N.; Uma, A.; Ahilan, B. and Antony, C. (2020)**. Metabolic responses of juvenile GIFT strain of Nile tilapia (*Oreochromis niloticus*) to dietary L-tryptophan supplementation. *Aquaculture Nutrition*, 26(5), 1713-1723. https://doi.org/10.1111/anu.13122

**Prangnell, D. I.; Castro, L. F.; Ali, A. S.; Browdy, C. L.; Zimba, P. V.; Laramore, S. E. and Samocha, T. M. (2016)**. Some Limiting Factors in Superintensive Production of Juvenile Pacific White Shrimp, *Litopenaeus vannamei*, in No-water-exchange, Biofloc-dominated Systems. *Journal of the World Aquaculture Society*, 47(3), 396-413. https://doi.org/10.1111/jwas.12275

**Ringnér, M. (2008)**. What is principal component analysis? *Nature Biotechnology*, 26(3), 303-304. https://doi.org/10.1038/nbt0308-303

**Sanaye, S. V.; Pise, N. M.; Pawar, A. P.; Parab, P. P.; Sreepada, R. A.; Pawar, H. B. and Revankar, A. D. (2014)**. Evaluation of antioxidant activities in captive-bred cultured yellow seahorse, *Hippocampus kuda* (Bleeker, 1852). *Aquaculture*, 434, 100-107. https://doi.org/10.1016/j.aquaculture.2014.08.007

**Torres-Ordónez, L. H.; Valenzuela-Cobos, J. D.; Guevara-Viejó, F.; Galindo-Villardón, P. and Vicente-Galindo, P. (2024)**. Effect of Genotype × Environment Interactions on the Yield and Stability of Sugarcane Varieties in Ecuador: GGE Biplot Analysis by Location and Year. *Applied Sciences*, 14(15), 6665. https://doi.org/10.3390/app14156665

**Trejo-Albarrán, R.; Flores-Ibarra, K. L.; Trujillo-Jiménez, P.; Granados-Ramírez, J. G.; Gómez-Márquez, J. L. and Sánchez, L. A. D. (2021)**. Water quality in fish farming ponds using some physical and chemical parameters. *Brazilian Journal of Animal and Environmental Research*, 4(4), 5490-5509. https://doi.org/10.34188/bjaerv4n4-049

**Valenzuela-Cobos, J. D.; Guevara-Viejó, F.; Cárdenas, J. and Lazo-Sulca, R. (2021)**. Chemical and productivity characterization of parental and hybrid strains of *Lentinula edodes* cultivated in different agricultural residues. *Emirates Journal of Food and Agriculture*, 33(3), 260-265. https://pdfs.semanticscholar.org/bb4c/fc4e93a011bfa6fef57e9f50528db97dbea3.pdf

**Valenzuela-Cobos, J. D.; Grijalva-Endara, A.; Marcillo-Vallejo, R. and Garcés-Moncayo, M. F. (2023a)**. Production and characterization of reconstituted strains of *Pleurotus* spp. cultivated on different agricultural wastes. *Revista Mexicana de Ingeniería Química*, 19(3), 1493-1504. https://doi.org/10.24275/rmiq/Bio1126

**Valenzuela-Cobos, J. D.; Guevara-Viejó, F.; Grijalva-Endara, A.; Vicente-Galindo, P. and Galindo-Villardón, P. (2023b)**. Multivariate Statistical Techniques: A New Approach to Identify the Commercial Properties of Mixtures of Flours of *Lentinula edodes* and Cocoa Pod Husk. *Journal of Fungi*, 9(10), 991. https://doi.org/10.3390/jof9100991

**Valenzuela-Cobos, J. D.; Guevara-Viejó, F.; Grijalva-Endara, A.; Vicente-Galindo, P. and Galindo-Villardón, P. (2023c)**. Production and Evaluation of *Pleurotus* spp. Hybrids Cultivated on Ecuadorian Agro-Industrial Wastes: Using Multivariate Statistical Methods. *Sustainability*, 15(21), 15546. https://doi.org/10.3390/su152115546

**Valenzuela-Cobos, J. D.; Guevara-Viejó, F.; Vicente-Galindo, P. and Galindo-Villardón, P. (2022)**. Food Sustainability Study in Ecuador: Using PCA Biplot and GGE Biplot. *Sustainability*, 14(20), 13033. https://doi.org/10.3390/su142013033

**Valenzuela-Cobos, J. D.; Guevara-Viejó, F.; Vicente-Galindo, P. and Galindo-Villardón, P. (2023d)**. Eco-Friendly Biocontrol of Moniliasis in Ecuadorian Cocoa Using Biplot Techniques. *Sustainability*, 15(5), 4223. https://doi.org/10.3390/su15054223

**Valenzuela-Cobos, J. D. and Rodríguez-Grimón, R. O. (2020)**. Biodegradation of plantain rachis using phytopathogenic fungi for composting. *Revista Mexicana de Ingeniería Química*, 19(2), 533-541. https://doi.org/10.24275/rmiq/Bio707

**Valenzuela-Cobos, J. D. and Vargas-Farías, C. J. (2019)**. Study about the use of aquaculture binder with tuna attractant in the feeding of white shrimp (*Litopenaeus vannamei*). *Revista Mexicana de Ingeniería Química*, 19(1), 355-361. https://doi.org/10.24275/rmiq/Bio615

**Varela, A. and Choc-Martínez, L. F. (2020)**. Diagnostic techniques for bacterial diseases in shrimp: Uses, scope and limitations. *Revista de Investigaciones Veterinarias del Perú*, 31(3), e18165. https://doi.org/10.15381/rivep.v31i3.18165

**Velásquez López, P. C.; Solorzano Reyes, J. F.; Ochoa Pereira, P. M.; Solano Motoche, G. W.; Quizhpe Cordero, P. and Guillen Añasco, R. M. (2023)**. Characterization of water quality during white shrimp (*Litopenaeus vannamei*) farming with freshwater in southern Ecuador. *Journal of the Selva Andina Animal Science*, 10(2), 74-87. https://doi.org/10.36610/j.jsaas.2023.100200074

**Villarreal, H. and Juarez, L. (2022)**. Super-intensive shrimp culture: Analysis and future challenges. *Journal of the World Aquaculture Society*, 53(5), 928-932. https://doi.org/10.1111/jwas.12929

**Walker, P. J. and Winton, J. R. (2010)**. Emerging viral diseases of fish and shrimp. *Veterinary Research*, 41(6), 51. https://doi.org/10.1051/vetres/2010022

**Wang, J.; Che, B. and Sun, C. (2022)**. Spatiotemporal Variations in Shrimp Aquaculture in China and Their Influencing Factors. *Sustainability*, 14(21), 13981. https://doi.org/10.3390/su142113981

**Zhao, J.; Zou, Y.; Chen, H.; Xu, J.; Liang, Z. and Xu, H. (2020)**. Effects of stocking density of Chinese soft-shelled turtle and interactions between cultivated species on growth performance and the environment in a turtle–rice coculture system. *Journal of the World Aquaculture Society*, 51(3), 788-803. https://doi.org/10.1111/jwas.12665