AGRI MAGAZINE
(International E-Magazine for Agricultural Articles)
Volume: 02, Issue: 09 (September, 2025)
Available online at http://www.agrimagazine.in

Integration of Traditional and Modern Diagnostic Approaches in Shrimp Aquaculture

*Ashfaq Ahmed S[1], Sakthi M[2], V Punnaivanam[3], Sambhaji Anandrao Awari[4] and T Satyanarayana[5]

[1]Spearhead of Laboratory, The Waterbase Ltd. (KCT), India
[2]Gen. Manager, Sales & Marketing, The Waterbase Ltd., Chennai, Tamil Nadu, India
[3]Managing Partner, Novakem Biosciences, Nellore, Andhra Pradesh, India
[4]Asst. Gen. Manager, Sales and Marketing, The Waterbase Ltd., Surat, Gujarat, India
[5]Regional Manager, Sales and Marketing, Deepak Nexgen Feeds Pvt Ltd, Nellore, Andhra Pradesh, India

*Corresponding Author's email: ashfaqjmc@gmail.com

Shrimp aquaculture has emerged as one of the most important contributors to the global seafood industry, particularly in Asia and Latin America. However, the rapid expansion of shrimp farming has also been accompanied by frequent and severe disease outbreaks, resulting in heavy economic losses. Viral diseases such as White Spot Syndrome Virus (WSSV), Taura Syndrome Virus (TSV), Yellow Head Virus (YHV), and bacterial infections like Acute Hepatopancreatic Necrosis Disease (AHPND) continue to threaten farm productivity. Accurate and timely disease detection is central to sustainable shrimp farming. Traditional diagnostic approaches such as gross pathology, histopathology, and microbial culture have been used for decades and continue to play a significant role. At the same time, modern molecular tools including PCR, real-time PCR, isothermal amplification methods like LAMP and RPA, immunoassays, and biosensors have revolutionized disease diagnostics with their sensitivity and specificity. Instead of considering them as competing methods, integration of traditional and modern diagnostic approaches provides a more reliable, holistic, and farmer-friendly strategy. This article explores the role of traditional and modern tools, their advantages and limitations, and discusses how integrating them can strengthen disease surveillance and control in shrimp aquaculture.

Picture: Shrimp farm

Traditional Diagnostic Approaches

Gross Clinical Examination: Farmers and technicians often begin with observation of shrimp behavior and visible symptoms. Lethargy, reduced feeding, discoloration, and unusual swimming patterns are early warning signs. Necropsy provides further clues, revealing changes in the hepatopancreas, gills, or gastrointestinal tract.

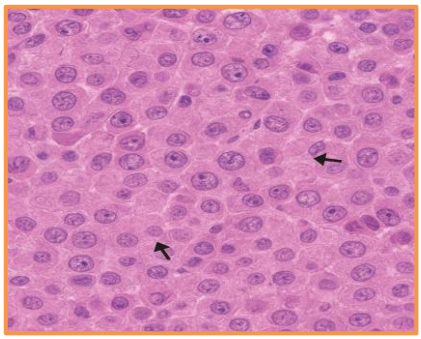
Picture: Healthy Shrimps

Picture: Unhealthy Shrimps

Advantages: Quick, inexpensive, and requires minimal equipment.
Limitations: Lacks specificity; many diseases cause overlapping symptoms.

Microscopy and Histopathology

Histopathological examination of organs such as gills, hepatopancreas, and gut tissues under light microscopy helps detect parasites, fungal filaments, or viral inclusion bodies. Special staining techniques add clarity, while electron microscopy provides ultrastructural details.
Advantages: Provides insight into tissue-level damage and co-infections.
Limitations: Requires technical skill, sample processing time, and laboratory infrastructure.



Picture: Histological slide showing hypertrophied nuclei in hepatopancreatic cells infected by WSSV.

Microbial Culture

Pathogens like *Vibrio* spp. can be isolated using selective media. Culturing helps confirm bacterial etiology and supports antibiotic susceptibility testing.
Advantages: Confirms bacterial cause and guides treatment.
Limitations: Some pathogens are unculturable; results take several days.

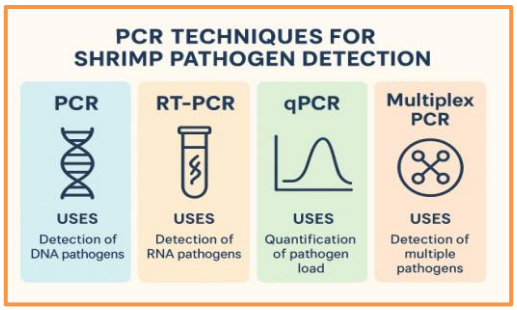
Immunological Methods

Techniques such as ELISA and immunohistochemistry are also considered traditional in aquaculture contexts. They detect antigens in tissues and fluids.
Advantages: Useful for pathogens difficult to culture.
Limitations: Requires high-quality antibodies and may lack sensitivity in early infections.

Modern Diagnostic Approaches

Polymerase Chain Reaction (PCR) and Variants

PCR has become a cornerstone of shrimp pathogen detection. Reverse transcriptase PCR (RT-PCR) helps detect RNA viruses, while real-time PCR (qPCR) provides quantification. Nested PCR increases sensitivity, making it effective for low-level infections.



Picture: Infographic comparing PCR, RT-PCR, qPCR, and multiplex PCR with their respective uses in shrimp pathogen detection.

Isothermal Amplification (LAMP, RPA)

Loop-mediated isothermal amplification (LAMP) and recombinase polymerase amplification (RPA) allow pathogen detection without thermal cyclers. These tests are faster, cheaper, and increasingly suitable for field deployment. Duplex RPA assays now enable simultaneous detection of diseases like AHPND and *Enterocytozoon hepatopenaei* (EHP).
Advantages: On-site applicability, short turnaround time.
Limitations: Requires validation and training.

Immunodiagnostics and Rapid Tests

Rapid immunochromatographic strip tests provide farmers with user-friendly detection kits for diseases such as WSSV. These tools are portable and offer results within minutes.

Biosensors and Next-Generation Tools

Recent advances include biosensors that employ peptides, aptamers, or nanomaterials for pathogen detection. Some patented diagnostic tools are designed specifically for rapid and low-cost detection of shrimp viruses in hatcheries.

Artificial Intelligence and IoT in Diagnostics

Smart monitoring systems integrate AI and Internet of Things (IoT) devices for water quality monitoring, image-based disease recognition, and predictive analytics. These approaches support early intervention even before clinical signs appear.

Picture: Screenshot of a mobile app displaying shrimp health monitoring data from IoT sensors.

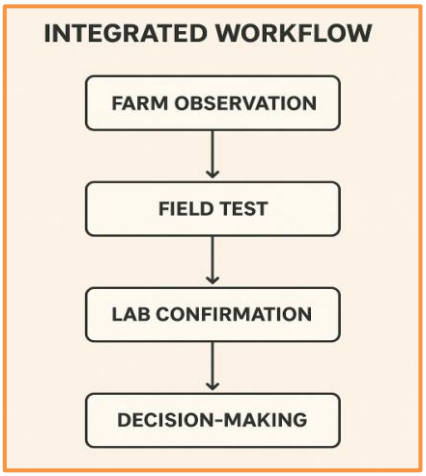
Comparative Analysis of Approaches

Parameter	Traditional Methods	Modern Methods
Cost	Low to moderate	Moderate to high
Infrastructure Need	Basic labs, microscopes	Specialized labs, PCR machines
Speed	Hours to days	Minutes to hours
Specificity	Moderate	High
Field Applicability	Good for gross exams	High with isothermal assays, rapid kits
Early Detection	Limited	Excellent

Integration of Traditional and Modern Approaches

An integrated diagnostic workflow combines the strengths of both systems:

1. **Routine Monitoring**: Daily gross observations and water quality checks.
2. **Trigger Sampling**: When abnormalities appear, collect shrimp for necropsy and microscopy.
3. **Rapid Field Diagnostics**: Use LAMP, RPA, or rapid immunoassays for suspected pathogens.
4. **Laboratory Confirmation**: PCR/qPCR for definitive diagnosis and pathogen quantification.
5. **Management Response**: Integrate results into farm management decisions partial harvesting, biosecurity tightening, or pond treatment.



Picture: Flowchart showing integrated workflow

Case Studies of Integrated Diagnostics

- **Philippines LAMP Kit for WSSV**: Farmers detected infections earlier than with standard lab PCR, reducing crop loss.
- **Duplex RPA-LFD for AHPND and EHP**: Allowed simultaneous detection in 35 minutes, supporting timely management.
- **India's Diagnostic Landscape**: While PCR labs exist, many farmers rely on histopathology and gross observations due to cost; integrated use is growing.

Challenges in Integration

- High cost of molecular kits and equipment.
- Short shelf-life and cold-chain requirements for reagents.
- Need for training farm workers to correctly use field kits.
- Standardization and regulatory approval of newer tools.
- Ensuring small-scale farmers in developing countries have access.

Future Perspectives

- **Multiplex Point-of-Care Kits** for simultaneous detection of multiple pathogens.
- **NGS and Metagenomics** for discovering emerging diseases.
- **AI and Big Data** for predictive disease models.
- **Affordable Biosensors** for smallholder farmers.
- **International Standardization** of diagnostic protocols for trade compliance.

Conclusion

Shrimp aquaculture's sustainability depends heavily on efficient and timely disease management. While traditional diagnostic approaches remain essential for routine monitoring and providing pathological context, modern molecular and biosensor-based tools have redefined the speed and precision of disease detection. Integration of both approaches represents the most reliable diagnostic model for farmers, laboratories, and policymakers. By combining the low-cost accessibility of traditional tools with the accuracy and sensitivity of

modern techniques, the shrimp industry can strengthen disease surveillance, mitigate economic losses, and ensure long-term sustainability.

References

1. Lee, Y., Vijayan, J., Roh, H., Kim, D. (2024). Nucleic acid amplification-based methods for diagnosis of shrimp viral diseases. *Reviews in Aquaculture*.
2. Simultaneous visual diagnosis of AHPND and *Enterocytozoon hepatopenaei* infection in shrimp with duplex RPA. *Journal of Applied Microbiology*, 2021.
3. On-site diagnostic kit identifies WSSV in shrimp. *Global Seafood Alliance*, 2020.
4. Adams, A. & Thompson, K.D. (2011). Development of diagnostics for aquaculture: challenges and opportunities. *Aquaculture Research*.
5. Lightner, D.V., Redman, R.M. (1998). Shrimp diseases and current diagnostic methods. *Aquaculture*.
6. ACS Agricultural Science & Technology (2023). An Indian Perspective on the Infection and Diagnostic Landscape of Shrimp Aquaculture.
7. PCAARRD, Philippines (2021). Technology to detect EMS of shrimp developed.
8. Global Growth Insights (2024). Shrimp Disease Diagnostics Market Report.
9. Kumar, V. et al. (2025). Disease in shrimp aquaculture: diagnosis and strategies. *Annals of Animal Science*.
10. AquaHoy (2024). Newly patented diagnostic tool for aquaculture pathogens.
11. Mdpi.com (2024). Integrating AIoT Technologies in Aquaculture: A Systematic Review.
12. IndustryResearch.biz (2024). Shrimp disease diagnostics market analysis.
13. Flegel, T.W. (2019). A future vision for disease control in shrimp aquaculture. *Journal of the World Aquaculture Society*.