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Sample Smart, Farm Smart: Using Sampling Techniques for Better Shrimp Farm Management

*Md Mukeem[1] and Dr. L. Surulivel[2]
[1]PG Scholar, Department of Aquaculture, Dr. M.G.R. Fisheries College and Research Institute, Ponneri-601204, Tamil Nadu, India
[2]Assistant Professor, Department of Fisheries Extension and Economics, Dr. M.G.R. Fisheries College and Research Institute, Ponneri-601204, Tamil Nadu, India
*Corresponding Author's email: mukeemkhan74530@gmail.com

Sampling is an active process in shrimp farming which requires accurate information on the stock. Being unable to assess each shrimp in the pond, sampling is an effective and cost-saving tool which allows gathering necessary information about the overall shrimp population. Correctly conducted sampling will allow farmers to estimate such parameters as the average body weight, growth rate, size distribution, biomass, survival, shrimp health condition, feeding behavior and water quality. This paper explains the basics of sampling methods applied to shrimp farming and describes the simple random, systematic, stratified and repeated sampling methods with particular focus on cast-net sampling. The paper explains the importance of representative sampling, proper sampling locations, right sampling time and technique, right sample size and absence of sampling bias. In addition, the paper describes how such simple statistical parameters as mean, range and standard deviation can be used to transform field observations into meaningful farm information. The sampling for growth monitoring, biomass estimation, feeding, health control and water quality is described. Finally, this paper demonstrates how modern technology, such as digital records, sensors, computer vision and artificial intelligence, can support the traditional sampling approach in smart shrimp farming.

Keywords: Sampling, shrimp farming, Penaeus vannamei, biomass estimation, growth monitoring, sampling bias, farm management, aquaculture statistics, smart aquaculture.

Introduction

Shrimp farming is an economic and biological activity which necessitates constant monitoring and decision-making. At each stage in the culture process, the farmer has to determine if the shrimp is growing appropriately, if the available feed is being efficiently consumed, the amount of biomass in the pond, if the survival rate is adequate, and any abnormality of the health condition. These decisions become more accurate if based on periodic measurement and not totally relying on visual examination or experience. However, in shrimp ponds, there are thousands or even millions of shrimps. There is no way the farmer could be able to sample and measure all of them. Sampling becomes a very important aspect in the management of the shrimp farm. Sampling entails the selection of fewer individuals or observations from a population. For instance, a shrimp farmer may sample a number of Penaeus vannamei from a pond using a cast net, weighs them and calculates their average body weight. This will provide useful information that can be compared with previous data in order to find out if growth is taking place as planned. Data obtained through sampling may also be used for biomass estimation and feeding decisions. FAO guidelines on shrimp farming note that sampling is an important management tool that helps in assessing growth and making feeding decisions (FAO, 2003; FAO, 2004).

Sampling is not just a statistical theory as presented in books. It is rather a real link between field observations and farming decisions. The basic principles of sampling may be outlined in a simple way: sample, measure, record, analyze, interpret and decide. But the value of the final decision largely depends on the way the sample was obtained.

Understanding Sampling in Shrimp Farming

Three terms are especially significant when talking about sampling: population, sample and representative sample. Population is the total group whose information is needed. In case of shrimp farming, it can be all the shrimp existing in a specific pond. Sample is a small group taken from the population for measurements and observations. However, the most important term is a representative sample. It is supposed to reflect the population well enough. For instance, consider the situation when a farmer takes 100 shrimp only from the area that is near to a feeding tray. In case larger or more active shrimp gather in this area, the average weight calculated might be higher than the real average weight of all the pond. Even though the farmer has taken a relatively big number of shrimp, the sample is biased. This shows the important statistical principle, that a big sample does not mean a good sample. Sampling technique and location matter as much as the size of the sample itself. As for population level surveillance, according to WOAH, it is important to design the sample according to the objective and give proper representation of the population investigated (WOAH, 2021).

Basic Sampling Techniques for Shrimp Farming

Various sampling methods can be adopted depending on the goals of the farm analysis. Simple random sampling means that sampling points or units are selected by chance. For instance, a farmer can split a pond into several sampling points and pick up locations for sampling randomly. This way of sample selection ensures that the chosen points are not selectively convenient and is especially relevant in situations when population estimation is the goal of sampling. Systematic sampling requires that samples are collected according to some pre-determined pattern or interval. A farmer may set up several sampling points at the pond and systematically collect samples according to a certain plan. The key benefit of this approach is consistency. In case the same general sampling technique is applied week after week, the measures will be easily compared. FAO recommends consistency of the sampling procedures during shrimps' growth measurement since change in the sampling method can affect the results (FAO, 2003). Stratified sampling may be used in situations where the pond has regions that differ greatly in their environments or shrimp populations. In such a case, the pond can be segmented into regions, which include aerated regions, feeding regions, central regions, and edges, and then samples can be taken from each of the regions. This ensures that the critical regions of the pond are covered.

Cast Net Sampling: A Practical Approach

Cast-net sampling is a feasible approach to obtain shrimp samples for routine growth monitoring in pond-based shrimp farms. With the help of cast-net, a number of shrimp can be trapped from an area of choice, from where these shrimp can be counted, weighted and physically examined. According to the FAO guidelines on shrimp growth assessment, cast-net sampling is a good method, but the sampling location and timing might affect the outcome (FAO, 2003). A good sampling procedure starts with selecting proper and representative locations. The same equipment and procedure should be followed in future samplings. The shrimp collected from chosen locations should be counted and weighted; it would be ideal if these are individually weighted. The farmer should record the day, time, location of sampling, as well as condition of sampled shrimp. Comparison with past data should be made. Regarding routine growth monitoring, according to FAO guidelines for shrimp pond culture, sampling a number of 50-100 shrimp in some cases could be a practical approach, while in some other cases taking several samples of lesser number could give better results (FAO, 2003). This does not constitute a rule that applies to all situations statistically speaking. The proper size of the sample depends on the objective of taking the sample, the variability of the population, and the level of accuracy needed. The timing of taking the samples also needs to be considered. The behaviour of the shrimps and the distribution of the shrimps can vary based on environmental conditions and time of the day. As mentioned by the FAO, there are some benefits of conducting cast-net sampling in times when the shrimps are more active and widely dispersed.

Sampling for Growth Monitoring

The first measurement that is simple yet quite informative is the Average Body Weight (ABW) of the shrimp. The formula is the sum of weights of the sample divided by the number of samples. For instance, the weight of 50 shrimp which is 400 g will yield the following average body weight:

$$\text{ABW} = 400\text{g} \div 50 = 8 \text{ g per shrimp.}$$

The farmer can compare his current ABW with those he had before for monitoring purposes. Increasing ABW indicates that the shrimp has grown heavier. Slow or irregular growth is usually due to some factors such as availability of feed, quality of water, stocking density and other factors. Nevertheless, ABW is not all there is to the picture. Two ponds may have the same average body weight but quite different in terms of size distribution. In one pond, the majority of shrimp may weigh 9 to 11 g while the shrimp in another pond weigh from 5 to 15 g each. However, the average body weight of both groups of shrimp will be close to 10 g. That is why it is useful to apply simple descriptive statistics. Information regarding the range of weights is provided by the minimum, maximum and range, whereas the standard deviation gives us information about the variability of individual measurements from the average. These are easy computations which may be applied to farm records and give information that cannot be seen when only the average weight is examined.

From Sampling to Biomass Estimation

Estimating the body weight of the shrimp is also done to calculate how much biomass exists in the pond. The formula used to calculate biomass is as follows:

$$\text{Biomass} = \text{Number of surviving shrimp x Body weight of shrimp.}$$

Thus, if there are 80,000 shrimps in the pond and each one has an average weight of 10 grams then the biomass will be roughly around 800,000 grams or 800 kilograms. There are many uses of calculating the biomass as this can be useful in determining feeding programmes as well as harvesting activities. However, the problem with using sampling technique for biomass calculation is that the result is an approximation and not an exact measurement. It means that any error that may have been made in calculating either of these figures will affect the overall result. It is because the shrimp are usually not evenly distributed throughout the pond. They tend to move on account of feeding, aeration and other environmental conditions. This makes it important to ensure that a sample collected at one point does not reflect the overall population.

Sampling and Feed Management

Feeds account for one of the significant operational expenses in shrimp farming and make it necessary to adopt feed management measures for profit maximization. Sampling can help in feed management through giving up-to-date information on the body weight and the biomass of the shrimps. The link is simple; sampling gives body weight information, body weight helps in estimating biomass, and biomass can be taken into consideration during feed review. According to FAO, it is crucial to assess the growth and biomass of shrimps in the process of feed management (FAO, 2004). However, it does not mean that feeds have to be changed depending on a sampling test alone. It is important to take into account feeding tray observations, feed usage, behavior of the shrimps, water quality and many other farm records. An increase in average body weight, for instance, must be viewed together with the reliability of the biomass estimate and previous feeding. Thus, sampling must be viewed as one of the elements of feed management rather than as a formula for determining feeds.

Where and When Should We Sample?

As crucial are the questions of "where" to sample and "when" to sample as the question "how many shrimps should we sample?" Shrimp distribution in a pond will depend on aeration, feeding, water circulation, depth, temperature and dissolved oxygen. Sampling at each occasion in the vicinity of the feeding area will introduce a bias since the shrimps sampled will be more active or larger while sampling around the pond edge may not cover the central region of the pond. In this regard, it is important to choose sampling locations which are representative of the pond. If there are any spatial differences, then it will be more beneficial to sample different regions rather than repeat sampling at a fixed point. Time is also important in sampling since environmental factors such as dissolved oxygen levels and even shrimp behavior might fluctuate depending on the time of the day. The best way to conduct regular sampling for growth measurement is to create a set time frame and try to keep everything constant as much as possible.

Sample Size, Sampling Error and Sampling Bias

The question often asked by farmers and students is, "What number of shrimp should be sampled?" Unluckily, there is no universal answer to this question since it is influenced by different factors such as the number of shrimp in the pond, variability, the reason for the sampling procedure, etc. To conduct a regular measurement of growth in shrimp, 50–100 individuals may be sufficient for sampling in certain pond culture systems. However, in case of disease surveillance, it is essential to note that sampling size is determined based on the aim of sampling, the expected prevalence of the infection and characteristics of the testing procedure. WOAH gives information regarding how to design surveillance and sampling procedures in case of aquatic animal diseases (WOAH, 2021). There are two important concepts associated with sampling: sampling error and sampling bias. First of all, sampling error appears due to the fact that samples represent only a certain part of the population. Therefore, the average weight of 50 shrimp may slightly differ from the average weight of all individuals in the pond. Sampling bias is not the same. It arises when the procedure is designed in a way that favors some particular shrimps or sites. Taking samples from big shrimps close to the food site is an easy illustration of sampling bias. The challenge with sampling bias is that it gives misleading results every time you sample.

Sampling for Shrimp Health and Disease

Shrimp sampling can present an opportunity to observe the overall state of farmed animals. The farmers may note any changes in coloration, swimming behavior, reaction to feeding, or abnormality in appearance. Such an observation can be the first step that indicates a problem that needs further investigation. Nevertheless, visual observation should not be considered as disease diagnosis. Many diseases can produce similar external symptoms, while some significant infections do not have obvious symptoms during the early stages of infection. In case of suspicion of disease, appropriate specimens need to be taken and analyzed by a proper laboratory. The sampling for disease purposes also should differ from the sampling during routine growth analysis. In cases of shrimp mortality, healthy shrimp may not always be the most effective specimens for disease diagnosis. According to the disease and method of diagnosis, recently deceased or diseased shrimp might be more suitable.

Water Quality Sampling

Shrimp sampling gives information about the shrimp, but the shrimp cannot be taken apart from their habitat. The quality of the water is one of the factors that affect the growth, behavior, stress level, and survival of the shrimps. Hence, the sampling of water quality is an integral part of the whole monitoring process. Some of the most commonly measured parameters in shrimp farming include water temperature, dissolved oxygen, pH, salinity, ammonia, nitrites, and alkalinity. In accordance with the recommendations of the Food and Agriculture Organization, water-quality monitoring should be a part of the management of shrimp ponds (FAO, 2003).

The water samples need to be taken considering the location, depth and time of the sampling. A single measurement of the water quality may not give the exact information about the whole pond and the whole cycle within a day. For instance, the content of dissolved oxygen can differ significantly depending on the time of the day. It is important to record the conditions during the measurement in order to make it more useful. The simultaneous keeping of shrimp growth data and water quality data can help farmers to establish a link between the two parameters.

From Traditional Sampling to Smart Sampling

Sampling practices that are currently used in shrimp farms are based primarily on hardware like cast nets, balances, water quality probes and pen-and-paper logs. New technologies now offer chances to improve monitoring efficiency. Mobile applications for managing shrimp farms could facilitate data logging and provide an opportunity for farmers to keep historical growth logs. Digital scales could decrease the error caused by manual calculations. Sensors would enable the constant monitoring of water quality parameters. Video equipment and computer vision could be used to analyze data such as the number of animals, their sizes and weight estimates. In the future, artificial intelligence could assist in integrating all this information into more efficient predictions. But technology does not replace the proper sampling procedure in any way. Bad data and incorrect data collection could lead to wrong results, no matter how advanced the analysis system is. Thus, the future of smart shrimp farming should not be interpreted as substitution of sampling with artificial intelligence. The future should rather be seen as the combination of correct sampling, good data, technology and farming experience.

From Sampling to Better Decisions

The main objective of the sampling program is not to gather numbers but to facilitate better decision-making. With a simple sampling program, a continuous cycle of information can be generated. The farmer first gathers the samples and proceeds with measurements on the shrimps. These observations are analyzed for average body weight, variability in sizes or other significant indices. These observations will then be interpreted together with the feeding, survival, and water quality data.

This entire process can be outlined as follows:

Sample → Measure → Record → Analyze → Interpret → Act → Monitor again.

With such cycle continuously being followed during the culture period, sampling can be more than just another routine farm practice. It can serve as a decision support system.

Conclusion

Because shrimp farming includes a large population of shrimps, it becomes difficult to measure all of them. This makes sampling an excellent means of acquiring information on growth, biomass, size distribution, feeding habits, health, and water quality of the shrimps. Proper sampling will ensure that the right sampling locations, periods, samples sizes, and sampling techniques such as random, systematic, stratified and repeat sampling are employed. Cast-net sampling is especially helpful in the case of routine growth assessment of the shrimps. With the development of shrimp farming digitally, sampling can be helped by sensors, electronic databases, computer vision, and artificial intelligence.

Sample Smart. Farm Smart. Grow Smarter.

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