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A Survival Function for Sustainable Shrimp Farming

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Survival rates of farmed shrimp depend on a number of factors such as water quality stocking density, feed etc Inappropriate management induces stress and diseases leading to low survival rate of shrimps Based on these relationships between factors an equation is developed to determine shrimp survival The shrimp survival function is estimated using the data from a field survey carried out in different farms of West Godavari district, Andhra Pradesh A non-linear version of Cobb-Douglass function provided best fit Ill-effects of linearization of a non-linear equation has been illustrated Preliminary results show that feed and seed management are significant in explaining shrimp survival rate It is also observed that water quality parameters have correct signs but with weak statistical significance The fitted nonlinear Cobb-Douglass function can be used for computing survival rates of shrimp in different farms of West Godavari district, Andhra Pradesh

(*Key words* *Survival function for shrimp farming Cobb Douglass function*)

According to Consultative Group International Agriculture Research (CGIAR) "Sustainable farming is the successful management of resources to satisfy the changing human needs while maintaining or enhancing the quality of environment and conserving natural resources" Farming system is said to be sustainable at the farm level if it satisfies the farmers needs (over time) while conserving natural resources Farmers satisfaction includes issues such as productivity profitability and social acceptability (Katyal 1997) The shrimp farming industry is characterized by boom and bust cycles (Csavas 1992 Jhonston 1997) The latter is due to outbreak of diseases and poor pond management which in turn leads to low production This causes direct impacts across all levels of economy especially the farmers who are directly involved and dependent on shrimp farming for their livelihoods Hence there is a need to find solutions to combat these situations An attempt was made in this study to quantify the factors governing the probability of disease outbreaks and to develop a survival function

MATERIALS AND METHODS

Good pond management is necessary to minimize disease outbreaks This includes stocking density seed quality feed management water quality management etc

Shrimp survival rates (SSR) are defined as the volume of shrimp harvested as a percent of which is expected at the end of the cycle Occurrence of disease (DISE) and stress (STRE) are the key determining factors in shrimp survival rate (Duriappah *et al* 2000)

$$SSR = f(DISE \ \ STRE) \qquad 1$$

However regressing of these factors on survival rate does not provide us any information for improved farm management We know that there is a relation between management practices and disease outbreak A model has been developed based on these relations

Eq 2 shows that disease outbreaks depend on pond water quality (WATE)

$$DISE = f(WATE) \quad 2$$

which in turn is influenced by the factors like feed (FEED), seed (SEED), pH (PH), biological oxygen demand (BOD), Salinity (SALI) etc

$$WATE = f(FEED\ SEED\ PH\ SALI\ BOD) \quad 3$$

The other key factor stress is also a function of seed and feed

$$STRE = f(FEED\ SEED) \quad 4$$

Substituting the eq 3 and eq 4 in eq 1 results in

$$SSR = f(SEED\ FEED\ PH\ SALI\ BOD) \quad 5$$

Eq 5 represents the shrimp survival function which is to be estimated. An advantage of replacing variables such as disease and stress levels is that these variables are difficult to quantify and data are difficult to obtain. The variables shown in eq 5 are easier to quantify and these data are generally available from field surveys. In this study Cobb-Douglass equation was experimented with the data. In general it is expressed as follows

$$Y = b_0\ X_1^{b_1}\ X_2^{b_2} \ldots X_n^{b_n} \quad 6$$

where Y is dependent variable X_1 X_2 ... X_n are independent variables and b_0 b_1 b_2 ... b_n are parameters or coefficients to be estimated

Cobb Douglass equation is a multiple nonlinear equation, and it is a common practice to linearize it for ease of calculations to estimate parameters under consideration. The linearized version of Cobb Douglass function is

$$\ln Y = \ln b_0 + b_1 \ln X_1 + b_2 \ln X_2 \ldots b_n \ln X_n \quad 7$$

The problem with this transformation is that nonlinear models are often derived on the basis of physical and/or biological considerations, e g from differential equations and have justification within a quantitative conceptualization of the process of interest. The parameters of a nonlinear model usually have direct interpretation in terms of the process under study. Furthermore some transformations alter the relationship between dependent and independent variables and experimental error will get distorted. Since the assumptions of linear regression are violated the values derived from the slope and intercepts of the regression line are not accurate determinations of the variables. To illustrate the ill effects of linearization the Cobb-Douglass function is fitted to data with and without linearizing the equation. To estimate the parameters of linearized version of the function ordinary least squares estimation method can be used ([illegible] 1983). As parameters appear nonlinearly in eq 7 nonlinear iterative techniques for estimation of parameters are to be employed. The methodology is similar to univariate nonlinear regression and these can be estimated by extending methodology of univariate nonlinear regression to multivariate non-linear regression (Gallant 1987). To test the adequacy of the fitted models the following goodness fit statistics were computed (D Agostiono and Stephens 1986)

i) Root Mean Squared Error (RMSE)

$$RMSE = \left[\sum_{t=1}^{n} (Y_t - \hat{Y}_t) / n \right]^{1/2}$$

ii Mean Absolute Error (MAE)

$$MAE = \sum_{t=1}^{n} \left| Y_t - \hat{Y}_t \right| / n$$

iii The data used in this study were collected from a survey of 25 shrimp farms situated in West Godavari district. Variables considered under study are SSR (shrimp survival percentage at each farm dependent variable) FEED (tonnes per hectare) SEED (stocking density per hectare) PH SALIN (salinity in ppt), BOD (biological oxygen demand in mg/l)

RESULTS AND DISCUSSION

As mentioned above Cobb-Douglass function is fitted to the data with and without linearizing the function The following stochastic regression equations are considered

A multiple nonlinear regression equation

$$SSR = (SEED)^a \times (FEED)^b \times (PH)^c \times (SALI)^d \times (BOD)^e + \varepsilon \quad 8$$

Linearized regression equation

$$\ln(SSR) = a\ \ln(SEED) + b\ \ln(FEED) + c\ \ln(PH) + d\ \ln(SALI) + e\ \ln(BOD) + \varepsilon \quad 9$$

The constant term is not included in both eq 8 and 9 because if inputs equal to zero then one would expect the output (survival) to be zero as well eq 8 and 9 are stochastic representation of eq 5 By utilizing standard statistical package S Plus 2000 the parameters are estimated for both the functions and presented in Table 1 From Table 1 it can be observed that the differences in the functional form yielded significant differences in estimated parameter values The linearized version of Cobb-Douglass functional form does not perform well as the nonlinear version For linearized version the parameter estimates of the seed are positive and significant as expected while the parameter estimates of the feed are insignificant and have the wrong sign Further, the standard errors for the parameter estimates are very high which indicates that linearzation of equation misleads the results The nonlinear version of the function parameter estimates for feed and seed are having correct signs significant and with low standards errors The estimates of water quality parameters are having the correct sign but with weak statistical significance The calculated RMSE (0 779) and MAE (0 229) are very low for nonlinear function when compared with linear function RMSE (15 339) and MAE (13 157) indicating that nonlinear form of the survival function is better when compared with linear form of survival function

Table 1. Parameter estimates and goodness fit statistics for the linear and nonlinear versions of Cobb Douglass survival function

Statistics	Linear version of Cobb-Douglass function	Nonlinear version Cob-Douglass function
i Parameter estimates		
a (feed)	-0 085(0 314)	0 067(0 029)*
b (seed)	0 179(0 084)*	0 198(0 024)**
c (p^H)	2 6179(0 628)**	2 463(0 649)**
d (salinity)	0 2107(0 494)	-0 159(0 44)
e (BOD)	-0 866(0 338)	-0 726(0 320)
ii Goodness fit statistics		
RMSE	15 339	0 779
MAE	13 157	0 229

Figures in parantheses are standard errors of the estimates

* significant at 5% level of significance ** significant at 1% level of significance

CONCLUSION

Based on calculated RMSE and MAE values nonlinear survival function was found to perform better than linear survival function. The parameter estimates also indicated that linearization of a nonlinear function leads to improper inferences which inturn leads to improper decision during policy making. Hence it is concluded that nonlinear function should be chosen for computing survival rates of shrimp farms of West Godavari district, Andhra Pradesh.

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