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A Method to Predict Hemorrhage Disease of Grass Carp Tends

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***Abstract*—**Hemorrhage Disease of Grass Carp (*HDGC*) is a kind of commonly occurring illnesses in summer, and the extremely high death rate result in colossal losses to aquaculture. As the complex connections among each factor which influences aquiculture diseases, there's no quit reasonable mathematical model to solve the problem at present.A *BP* neural network which with excellent nonlinear mapping coherence was adopted to establish mathematical model; Environmental factor, which can easily detected, such as breeding density, water temperature, pH and light intensity was set as the main analyzing object. 25 groups of experimental data were used for training and test, and the accuracy of using the model to predict the trend of *HDGC* was above 80%. It is demonstrated that *BP* neural network for predicating diseases in *HDGC* has a particularly objectivity and practicality, thus it can be spread to other aquiculture disease.

***Keywords*—**Aquaculture, Hemorrhage Disease of Grass Carp, *BP* Neural Network

I. Introduction

IN conventional aquaculture process, occurrences of infectious diseases are frequent. Different breeding density, temperature, and pH in complicated breeding environment can affect the spreading and the extensiveness of the disease, resulting in indeterministic prediction and untimely response to the controlling of a rapidly spreading epidemic outbreak.

Grass Carp is bred extensively in China. Every year, from June to October, it's the spreading period of Hemorrhage Disease of Grass Carp; especially in August. That takes a huge loss every year. Despite a great deal of people did various researches on the cure of Hemorrhage Disease of Grass Carp, only with the method relying on experience to predict the trend with different breed conditions of Hemorrhage Disease of Grass Carp, it couldn't achieve any scientific prediction or analysis.Applications of artificial neural network (*ANN*) for predicating realities have been widely accepted and proven to have good predictiveness [1], [2]. As the aquafarming environment monitoring advances [3], sets of empirical data of aquaculture are becoming accessible easily. These data are used in the creation of the artificial neural network predication model for the disease trend of aquaculture.*ANN* as a parallel algorithm [4] has very good nonlinear mapping coherence, requiring less empirical data of the modeling target and less knowledge of the internal structure of the model, rather relying on input/output weights flowing through the learning process for getting the mapping relationship of input and output. The adoption of *ANN* gives the advantage of coherence to the simulation of disease dispersion in aquafarming and the realization of the predication curve of disease occurrence of aquatic breeds. In this paper, an analysis is done through experiments conducted over 25 sets of empirical data of grass carp hemorrhage cases by using breading density, water temperature, pH, light intensity, dissolved oxygen, and nitrogen concentration as input weighing factors for the training phase in the model. The results are found with good accuracy so the effectiveness and adaptability of the model can be applied for disease predications and analyses of diverse aquatic breeding.

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II. Materials and Methods

As the aquacultural environment monitoring advances, vast volume data sets of aquacultural environment are becoming accessible easily and used to analyze the abnormal conditions of existing aquaculture, water quality, and temperature not conducive to the survival of aquatic breeds.

Monitoring criteria may vary with aquatic assortments; however, they can be categorized as below:

1) Breeding Density: A deterministic factor for the disease spreading speed, the denser, the faster; 2) Water Temperature: An influential for the reproduction and dissemination of viruses, parasites, especially, fish activities and survival; 3) pH: Soluble glue-like alkaline protein salt formed by over-concentrated alkaline water and proteins from gills or other organs will cause fish and shrimp deaths of morphological hyaline change and breathing difficulties. In water with increased acidity, bacteria reproduction accelerates; fish are more vulnerable to infectious diseases, leading to increased morbidity and mortality; 4) Light Intensity: Light intensity has effects on fish activities as well as other aquatic creatures; 5) Dissolved Oxygen (*DO*): For normal undergoing metamorphosis of aquatic animals, adequate supply of oxygen underwater is essential. Dissolution of oxygen affects closely with the survival of aquatic animals; 6) Nitrogen Concentration: The transformation of ammonia into nitrate consumes tremendous *DO* in water, especially *NH3* poisonous to fish and other aquatic creatures; even with light concentration is inhibitive to growth, harmful to gill organ and worsening fish morbidity; 7) Sulfide: Sulfide brings irritation and corrosion to gills, causing coagulation necrosis and death

of suffocation; 8) Nitrite: Nitrite content in aquaculture waters is a critical element inducing outbreaks of diseases of aquatic animals.

25 samples are collected from grass carp hemorrhage cases with the data of the breeding environment, amongst, 12 are cultivated with the same method in the laboratory and the other 13 are mixed with other aquafarms. The statistic data includes breeding density, water temperature, pH, light intensity, precipitation, *DO* and the death rate of grass carp due to hemorrhage.

Regularity and correlation of disease spreading are closely simulated in the ANN training phase with the past empirical and experimental data so that the results of predication would match as closely as possible to the epidemicity of disease.

The predication of the trend of the disease occurrences is achieved by using the environ data a few days before the disease outbreak as input, disease types as the setup of hidden layers, and the curve of onsets and death rate varying with time during the outbreak period as the simulation output.

BP Network

BP Network [5], a propagation network derived from artificial neural network perception, can adaptively change its structure based on information that flows through the network during its training phase so as the automatic analysis of the data to find its regularity and interconnection for a specific pattern. The identified pattern is reflected onto the structure by assigning weights to the connections of synapses (nodes) inside the network to produce a desired signal flow. The trained model can then be used to predicate subjects with similar criteria.

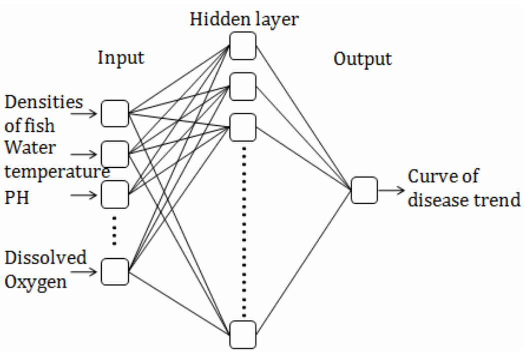

Fig. 1 Disease Trend Predication BP Network Input/output Model; Left Layer - Input Factors, Middle Layer-Hidden, Right Layer- Output -Death Rate

BP Network is a multiplayer feed-forward neural network. The transfer function for neuron is S-function. The basic formation of the network has three layers – Input, Hidden and Output. The *BP* algorithm primarily uses the difference between actual output and the expect value to automatically make forward adjustments of the interconnection strength between layers. During an application, one hidden layer can realize any non-linear mapping relationships of input and output; therefore, theoretically, a single layer neural network is adequate to simulate the inner relationship of aquaculture disease and environment.

Model

The predication of the trend of the disease occurrences is achieved by using the environ data a few days before the disease outbreak as input, disease types as the setup of hidden layers, and the curve of onsets and death rate varying with time during the outbreak period as the simulation output. Considering disease influentials including temperature, precipitation, breeding density, light intensity and the size of fish pond of the epidemicity of grass carp hemorrhage, as well as the disease spreading factor of pH and *DO*, the breeding density, water temperature, pH, light intensity, precipitation, dissolved oxygen are chosen as the input weighing factors to the *BP Network* model.Since factors chosen are in different units with large variances among them, normalization is applied to all input factors to restrict input values to be in (0, 1) value range. The normalization formula used is given below:

$$x^* = \frac{x - x_{\min}}{x_{\max} - x_{\min}}$$

Output Variables

The duration of the predication curve is set contingent upon the disease cycle. According to experimental data, the disease cycle for grass carp hemorrhage is set to 17 days. Output is defined to be a 2D curve with its Horizontal Axis – Time and Vertical Axis – Onset or Death Rate.

Training

In *Matlab*, *newff* function is used to initialize the network. Transfer function ***S***-function is $f(x) = \frac{1}{1+e^{-x}}$. The training function is the optimized *Levenberg-Marquardt (LM)* [6].

The advantage of *LM* is that network weights will be smaller and converge faster [7]. The optimized *LM* algorithm has less iteration, fast convergence and high precision than conventional *BP* and others (e.g. conjugate gradient method, additional momentum, and adaptive adjusting methods).

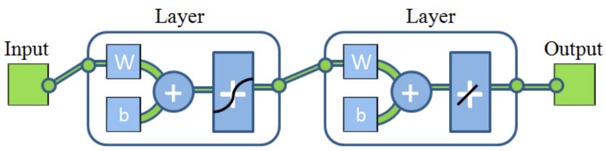

Fig. 2 Neural Network Model Structure of Grass Carp Hemorrhage Predication

The working neural network predication model is done through construction and training by programming. For better control and being responsive to take proper measures timely, the curve of the outbreak of disease is output as a function of time.

III. Results and Discussion

Stochastic outcomes are generated during the training phase of the neural network. Therefore, different iterations are incurred in the training phase. However, as long as the deviation of training result is within tolerance, the training will be ended normally. The table below tabulates one deviation out of multiple training processes:

TABLE I
EXPERIMENTAL SAMPLING AND PREDICATION OF GRASS CARP HEMORRHAGE

Time/Day	The Death Rate of Experiment	The Death Rate of Predict	Relative Error
1	0%	0.47%	1.36%
2	6.53%	6.62%	3.02%
3	13.99%	13.58%	5.18%
4	16.85%	16.02%	0.94%
5	16.03%	15.88%	5.42%
6	13.41%	12.72%	7.44%
7	10.33%	11.16%	0.94%
8	7.53%	7.46%	8.90%
9	5.26%	4.83%	8.23%
10	3.57%	3.89%	15.12%
11	2.36%	2.05%	19.53%
12	1.53%	1.28%	10.23%
13	0.97%	0.88%	49.17%
14	0.61%	1.20%	40.74%
15	0.38%	0.27%	39.47%
16	0.23%	0.38%	56.25%
17	0.14%	0.32%	1.36%

Time duration is set from the start of the disease outbreak to the end of the outbreak; The death rate of experiment is the daily death rate vs. the total death rate; The death rate of the experiment predicates the daily death rate vs. the total death rate; Relative Error=|Experiment-Prediction|/Experiment.

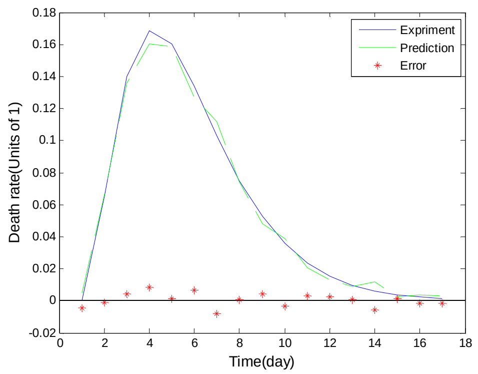

Fig. 3 Actual Death Rate Curve & Predicated Curve by Model; Aquaculture Criteria: Temp. = 28℃, pH = 6.3, DO=4, etc

From data given in the table, the results between the experiments and the predicated by the model are nigh. Relative errors observed, for 17-day cycle, are 16.08%, 4.0% for 9-day cycle and 28.98% for 8-day cycle, respectively. The predicated relative error at the early stage of the disease outbreak is considerably small but becoming large at the final stage of the outbreak. This is due to death occurrences of grass carp hemorrhage concentrate in the early half of the cycle and drop significantly at late stage. The deviation formula uses the absolute error divided by the actual death rate, when the death rate drops significantly, the relative error increases accordingly. For Figure 3, trends of the predicated and the actual death rate demonstrate comparability. Even for the outstanding case at the 14th day, the predication is acceptable. This shows the predication model is effective and applicable.

Under the aforementioned aquaculture criteria, when the death rate of grass carp hemorrhage reaches 15% of the total cultivation volume, through curve integration, the disease outbreak time can be estimated as ***T = 2 + Disease Latency***. Fish deaths are concentrated around the 4th day. This is coincided with the actual disease outbreak of grass carp hemorrhage in high-density aquaculture environment. The model so then can be used for the estimation of the time of the disease outbreak and the predication of the disease occurrence trend from the aquaculture criteria and the death rate of the future occurrence of grass carp hemorrhage case.

IV. CONCLUSIONS

Neural network has its advantage in solving predications of non-linear complex problems. It uses empirical or experimental data to train its network to find automatically the pattern of regularity and interconnection of diverse factors that affecting disease spreading in an aquacultural environment.

With some simple input factors, as demonstrated in the study, such as the volume and size of cultivation as the characteristic criteria, similar predication model with small relative error can be achieved. The internal mapping is the correlation of certain criteria with the breeding density. By modifying the characteristic criteria, a better model with adaptability for other aquaculture disease predication can be obtained.

From the study, applying neural network on predicating of the disease occurrence trend of grass carp hemorrhage cases is applaudable. The use of the basic factors such as breeding density, water temperature and pH in analyzing regular aquaculture environment combined with the past empirical data of actual disease outbreak as the training data for the model, the trained model can provide high sensitivity and small relative error in predicating grass carp hemorrhage disease outbreak case.

Since lacking of actual predication model for aquaculture diseases trends, few references are available so as other models for comparison, this model for aquacultural disease predication based on neural network is a new attempt. More experiments to prove further its adaptability and effectiveness for other aquaculture disease are needed.

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