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Fuzzy Matrix Analysis in Aqua Culture

Research Article

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Abstract: Fuzziness is a fruitful concept introduced by Zadeh to eradicate the vagueness arising in quite common datas of real world problems. It has been found extensive applications in the field of Decision making.Aquaculture is a fast developing industry with great focus on feeding behavior. This paper is devoted to choose the appropriate feed, in which the uncertain information gathered by experimentally using Azolla microphyla as a feed to the fishes Cyprinus Carpio, analysed using Fuzzy Matrices. Using the concept of ATD, RTD, CETD fuzzy matrices the best feed level is decided for the fish Cyprinus Carpio.

MSC: 15B15.

Keywords: Azolla microphylla, ATD, RTD, CETD, Decision making, Cyprinus Carpio.

1. Introduction

Azolla is an aquatic pteridophyte widely distributed in the water bodies. It has been traditionally used as a bio fertilizer for rice paddy fields owing to its potential to fix atmospheric nitrogen [13]. In addition to this it has several other uses and Wagner [28] referred it as "green gold mine". The plant system has the inherent capacity to synthesize several biologically active constituents which in turn protect them against the attack of insects and other plant pathogens such as bacteria and Fungi. Plant phenolic seems to be one of the important factors that evoke host plant alternation and the flavonoids are reported to exhibit various biological activities, including antioxidative and free radical scavenging activities [3, 19]. Recently the utilization of aquatic plants having high food value are used to supplement fish food has taken a new dimension for producing the much required animal protein at low cost .Azolla, which grows in association with the blue green algae Anabaena Azolla, is perhaps the most promising from the point of view of ease of cultivation productivity and nutritive value [14, 26]. Fish require diets relatively higher in protein than those of commercially cultured animals. As protein represents the most expensive component in a formulated diet, it is considerable practical importance to determine the optimum level that will support maximum growth and survival [22]. Azolla is rich in protein; other constituents in Azolla are minerals, chlorophyll, carotenoids, amino acids, vitamins etc. It is also potential source of nitrogen and is a potential feed ingredient for livestock [14, 16].

Azolla is very rich in proteins, essential amino acids, vitamins (vitamin A, vitamin B12, Beta carotene) growth promoter intermediaries and minerals including calcium, phosphorus, potassium, ferrous, copper, magnesium. On a dry weight basis,

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Azolla has 25-35% protein content, 10-15% mineral content and 7-10% Comprising a combination of amino acids bio-active substances and biopolymers [11] Carbohydrate and oil content is very low in Azolla. Azolla is also rich in iron (1000-8600 ppm dry weight), copper (3-210 ppm dry weight) manganese (120-2700ppm dry weight), Vitamin A(300-600ppm dry weight), chlorophyll and carotenes. It contains 4.8-6.7 % dry weight crude fat with 6.1-7.7 % and 12.8-26.4% total fat for the polyunsaturated acids omega 3 and omega 6 [17].

Improved feed utilization in Tilapia mossambica [22] and increased growth in Rohu [11], Niletilapia [9], common carp .silver carp, rohu and mirgala(Tuladhr, 2003) have been reported upon inclusion of Azolla in feeds. Sivakumar and Solaimalai (2003) have observed beneficial effects of feeding fresh and dried Azolla to O.niloticus in integrated rice-fish culture system.According to Majhi et.al., (2006), utilization of organic Azolla through grass carp is one of the best options for the production of fish biomass from the aquatic habitat. The common carp (Cyprinus carpio) belongs to the family Cyprinidae and is one of the most important culture fish in the world and especially in Asia. Cyprinidae culture in recent decade has developed noticeably in different countries due to their extensive culture [24]. Common carp, Cyprinus carpio, is one of the most important fish speciesin aqua culture [21] . Common carp is an economically significant fish species in that cultivated common carp was about 6.14% of the global aqua culture production (FAO Yearbook, 2008). Nutritive value of Azolla for fish was explained by Joseph [10]. utilization of sun dried Azolla by young and adult of other cultivatable herbivorous and omnivorous species has been reported earlier [2, 10, 18]. El-sayed (2008) [7] noted that young Niletilaphia utilized Azolla more efficiently than adults. Sheeno and Sagu (2006) [20] reported that Azolla protein concentrate is a good source of protein can be used up to 16.25% by replacing 10% fish meal in the diet of Labeo rohita fry.

According to [11], Azolla can be incorporated upto 25% in the diet of the Labeo rohita.Fiogbe [9] fed O.niloticus with diets containing dry Azolla meal at 0, 15, 20, 30, 40 and 45% of diets. They concluded that the least expensive diet containing 45% Azolla can be used as a complementary diet for tilapia raised in fertilized ponds.Ebrahim [5] incorporated sun dried and ground A.nilotica at 10.6, 21.2, 31.8 and 42.2% levels in the diet of O.niloticus. Ebrahim [5] have also investigated, diets were fed to Nila tilapia Oreochromis niloticus fingerlings with initial mean body weight of 8.1 g$^+_-$ 0.3 g at 3% of fish biomass daily for 90 days. The obtained results revealed that Azolla meal(dried pellet form) is a suitable component for Nile Tilapia fingerlings diets since growth performance in all tested and control diets were nearly similar without significant differences.

The notion of fuzzy sets introduced by Zadeh [29] in 1965 is one of the most fruitful models of uncertainty and has been extensively used in real life applications. Fuzzy set theory also plays a vital role in the field of Decision Making [12]. Decision Making is a most important scientific, social and economic endeavor. In classical crisp decision making theories, decisions are made under conditions of certainty but in real life situations this is not possible which gives rise to fuzzy decision making theories.

In this paper the data obtained experimentally has been subjected to data mining technologies using Fuzzy matrix theory .The application of Fuzzy matrix to the prediction of biological values has been attempted previously in many cases of health care issues like cancer and also nutrition [12]. A premiere attempt to apply the same to test the feed efficiency in different types of feed used in aqua culture has been done in this paper.

2. Methodology

Five different types of feed viz. D_1 (control(10%level)), D_2 (20% level), D_3 (30% level), D_4 (40% level), D_5 (50% level) were prepared using Azolla micropylla and given to test fish Cyprinus Carpio for 30 days. During the feeding trial, the fishes accepted the different diets but variations were noted in different parameters such as growth and blood parameters. The length and weight of the test animal was noted initially and at 7 days interval. The experiment and subsequently growth rate, feeding rate, specific growth rate, feed conversion ratio, gross conversion efficiency and survival rate in C.carpio fed on five different diets are shown in table. The concept used in Fuzzy matrix as follows.

Step 1: Choose the set of parameters for the experiment.Tabulated the output of the experiments. It is called the Raw Data Matrix.

PARAMETERS	Control (D_1)	20% (D_2)	30% (D_3)	40% (D_4)	50% (D_5)
Initial Length(cm)	2.75 ± 0.17	3.65 ± 0.11	3.65 ± 0.11	3.4 ± 0.07	3.85 ± 0.17
Final Length(cm)	5.25 ± 0.16	6.25±0.28	5.75 ± 0.17	6 ± 0.14	6.5 ± 0.35
Initial Weight (g)	3 ± 0.35	2.68 ± 0.12	2.95 ± 0.03	2.5 ± 0.21	2.75 ± 0.11
Final weight(g)	4.33 ± 0.23	4.1 ± 0.28	4.45 ± 0.31	4.49 ± 0.07	4.75 ± 0.17
Growth rate	1.33 ± 0.12	1.42 ± 0.12	1.5 ± 0.21	1.99 ± 0.20	2.5 ± 0.35
Feed conversion ratio(FCR)	6.74 ± 0.16	6.89 ± 0.13	4.66 ± 0.11	7.04 ± 0.114	4.87 ± 0.19
Specificd growth rate(SGR)	11.93 ± 0.65	14.20 ± 0.49	15.52 ± 0.72	18.65 ± 0.46	19.29 ± 0.19
Gross conversion Efficiency	14.82 ± 0.93	14.19 ± 0.84	14.49 ± 0.36	20.5 ± 0.56	21.44 ± 0.45
Feeding rate	0.099 ± 0.01	0.113 ± 0.002	0.116 ± 0.004	0.124 ± 0.002	0.129 ± 0.006
Assimilation	4.7 ± 0.14	6.3 ± 0.21	7.3 ± 0.21	8.04 ± 0.11	8.4 ± 0.21
Assimilation efficiency	2.57 ± 0.26	3.35 ± 0.31	3.73 ± 0.16	3.97 ± 0.33	4.04 ± 0.04
Survival rate	55%	65%	70%	80%	95%

Step 2: Find the Average Time Dependent Matrix (ATD Matrix).

FEED CONTROL LEVEL	I.L	F.L	I.W	F.W	G.R	FCR	SGR	GCF	FR	A	AE
0-10	0.275	0.525	0.3	0.433	0.133	0.674	1.193	1.482	0.009	0.47	0.257
10 20	0.365	0.625	0.268	0.41	0.142	0.689	1.42	1.419	0.0113	0.63	0.335
20-30	0.365	0.575	0.295	0.445	0.15	0.466	1.552	1.449	0.0116	0.73	0.373
30-40	0.34	0.6	0.25	0.449	0.199	0.704	1.865	2.05	0.0124	0.804	0.397
40-50	0.385	0.65	0.275	0.475	0.25	0.487	1.929	2.144	0.0129	0.804	0.404

Step 3: Using the formulas, $\frac{\sum x}{n} = \mu$ and $\sqrt{\frac{\sum x^2}{n} - \left(\frac{\sum x}{n}\right)^2} = \sigma$. Find μ, σ the mean and standard deviation of the given parameters. The Average (μ_j) and Standard Deviation (σ_j) of the ATD matrix as follows:

μ_j	0.346	0.595	0.2776	0.4424	0.1748	0.604	1.5918	1.708	0.01144	0.6876	0.3532
σ_j	0.03493	0.03926	0.01666	0.01937	0.04016	0.09562	0.25116	0.29119	0.00123	0.11515	0.04912

Step 4: Using the conditions,

$$\begin{cases} a_{ij} \leq (\mu_j - \alpha * \sigma_j), & \text{then } e_{ij} = -1.; \\ a_{ij} \in (\mu_j - \alpha * \sigma_j, \mu_j + \sigma * \sigma_j), & \text{then } e_{ij} = 0.; \\ a_{ij} \geq (\mu_j + \sigma * \sigma_j), & \text{then } e_{ij} = 1. \end{cases}$$

Form the Refined Time Dependent Data Matrix (RTD Matrix) for different values of $\alpha \in [0, 1]$.

$$\text{RTD1 : For } \alpha = 0.30 \qquad \text{Row Sum}$$

$$\begin{pmatrix} -1 & -1 & 1 & -1 & -1 & 1 & -1 & -1 & -1 & -1 & -1 \\ 1 & 1 & -1 & -1 & -1 & 1 & -1 & -1 & 0 & -1 & -1 \\ 1 & -1 & 1 & 0 & -1 & -1 & 0 & -1 & 0 & 1 & 1 \\ 0 & 0 & -1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 0 & 1 & 1 & -1 & 1 & 1 & 1 & 1 & 1 \end{pmatrix} \begin{pmatrix} -7 \\ -4 \\ 0 \\ 7 \\ 8 \end{pmatrix}$$

$$\text{RTD1 : For } \alpha = 0.60 \qquad \text{Row Sum}$$

$$\begin{pmatrix} -1 & -1 & 1 & 0 & -1 & 1 & -1 & -1 & -1 & -1 & -1 \\ 0 & 1 & 0 & -1 & -1 & 1 & -1 & -1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & -1 & 0 & -1 & 0 & 0 & 0 \\ 0 & 0 & -1 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 0 & 1 & 1 & -1 & 1 & 1 & 1 & 1 & 1 \end{pmatrix} \begin{pmatrix} -6 \\ -2 \\ -1 \\ 6 \\ 8 \end{pmatrix}$$

$$\text{RTD1 : For } \alpha = 0.90 \qquad \text{Row Sum}$$

$$\begin{pmatrix} -1 & -1 & 1 & 0 & -1 & 0 & -1 & 0 & -1 & -1 & -1 \\ 0 & 0 & 0 & -1 & 0 & 0 & 0 & -1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & -1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & -1 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 0 & 1 & 1 & -1 & 1 & 1 & 1 & 1 & 1 \end{pmatrix} \begin{pmatrix} -6 \\ -2 \\ 0 \\ 5 \\ 8 \end{pmatrix}$$

Step 5: By combining all the RTD Matrix, Find Combined Effect Time Dependent Data Matrix (CETD Matrix) which gives the cumulative effects of the parameters in the final output.

CETD Matrix:

$$\text{CETD} \qquad \text{Row Sum}$$

$$\begin{pmatrix} -3 & -3 & 3 & -1 & -3 & 2 & -3 & -2 & -3 & -3 & -3 \\ 1 & 2 & -1 & -3 & -2 & 2 & -2 & -3 & 0 & -1 & -1 \\ 1 & -1 & 3 & 0 & -1 & -3 & 0 & -2 & 0 & 1 & 1 \\ 0 & 0 & -3 & 1 & 2 & 3 & 3 & 3 & 2 & 3 & 2 \\ 3 & 3 & 0 & 3 & 3 & -3 & 3 & 3 & 3 & 3 & 3 \end{pmatrix} \begin{pmatrix} -19 \\ -8 \\ -1 \\ 16 \\ 24 \end{pmatrix}$$

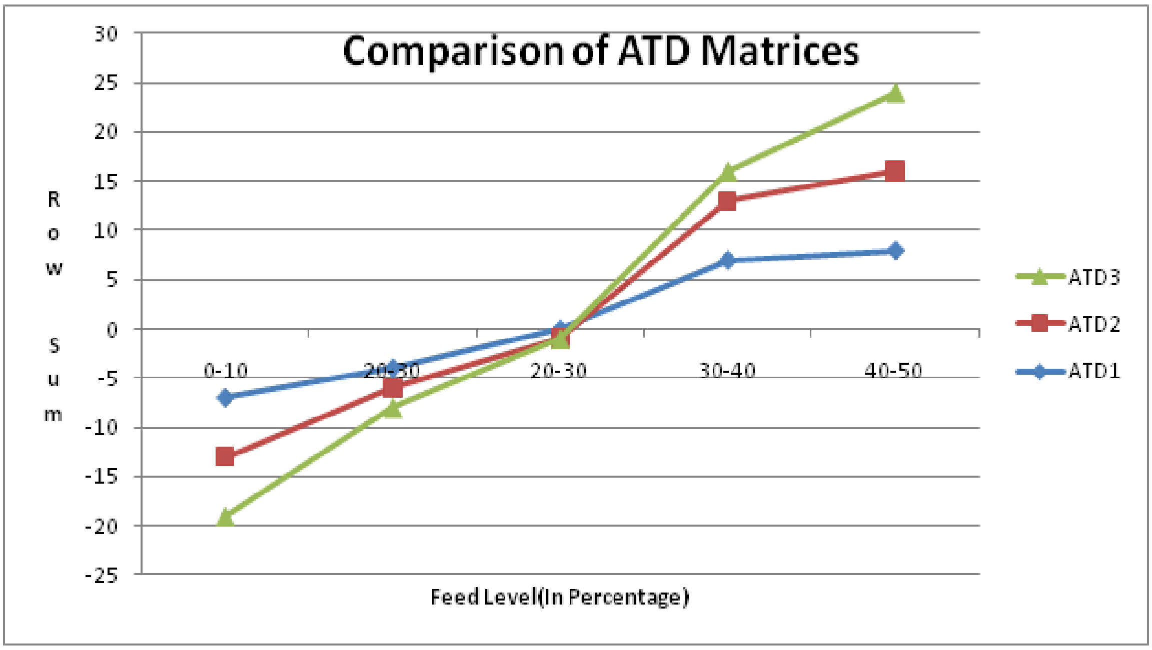

Figure 1. **The Comparison Chart Between the Three ATD Matrices**

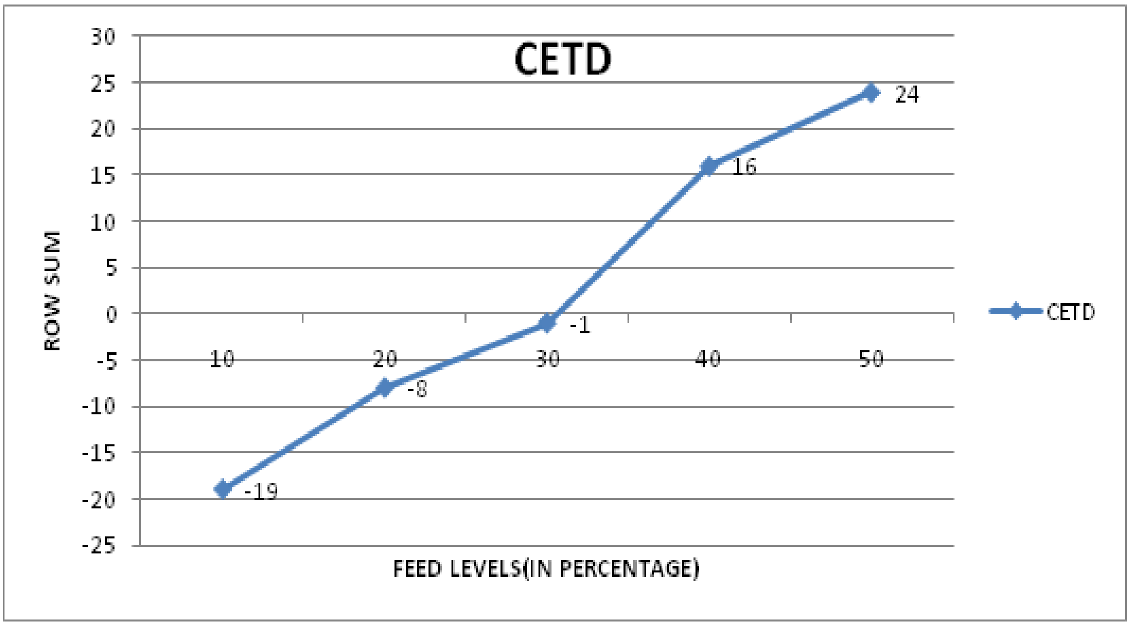

Figure 2. **The Graphical Representation Of CETD Matrix**

The RTD Matrices and CETD matrix are formed using the MATLAB software and the charts are prepared using Microsoft Excel Sheet. From the graphical representation of CETD matrix, the feed with 50% control level is the best diet for the fish Cyprinus Carpio.

3. Conclusion

The above experiment was conducted using the experimental data of the growth parameters of Cyprinus Carpio fish using different diets.In Aqua culture fish feed is a very important factor determining the growth and health of the fishes .They also take up much of the expenditure in an aquaculture farm. In this paper the fuzzy ATD , RTD and CETD matrix concepts are adopted to determine the best type of feed which is more suitable and economical .The fuzzy logic used here to transforms the data into Time dependent matrices.With these matrices we are able to identify the best suitable diet for the fish Cyprinus Carpio. The results of the Fuzzy matrix model gave the exact result as that obtained experimentally.

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