Mathematical modeling of fish-productivity of Sirpur Lake, Indore, India

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ABSTRACT

The present work gives us an idea of the transgression of fresh water fishes of Sirpur Lake. Sirpur Lake is perennial water body and fish producing unit. 26 species belonging to 13 families of fish were collected from this lake. Fish collected were major and minor carp, live fish, Eels, and catfishes. All the fish are consumed by the local people of the Indore city. A careful and scientific management will increase the fish productivity. The annual production of fish (2001 – 2002) of the Sirpur Lake was obtained from the local fishermen during harvesting seasons. The present worker also participated during harvesting periods for the collection of data. The following mathematical model of productivity was devised for the different species of fishes in Sirpur Lake:

$$\Delta P_n = P_n - P_{n-1}$$
$$P_n \propto f(P_{n-1})$$
$$\Delta P_n = B_n f_1(P_{n-1}) - D_n f_1(P_{n-1})$$

where,
P_n = Population of the given species and domain after 'n' generation.
$f(P_n)$ = Fish population of the given species and domain after 'n' generation
B_n and D_n are respectively parameters for birth rate and death rate.

INTRODUCTION

Fish Production
Viewing the vast areas of water bodies, it is quite natural to expect high fish production in India. Unfortunately fish production per capita fish consumption in India is the lowest in comparison to other countries like Japan, Korea, Taiwan, and Malaysia. Fish production is largely dependent on aqua culture management, however, increase in human population and industrialization have created the problem of waste disposal and there is a heavy load of waste in rivers, lakes and other water bodies which make them unfit for aquaculture (Lagler, 1956)

MATERIAL AND METHODS

Fishes were collected in different seasons with the help of local fisherman for a period of two years from monsoon 2001 to Summer 2002. The fishes collected were preserved in 5% formalin and identified after Day (1878) and Jayaram ( ).

FISH PRODUCTIVITY OF SIRPUR LAKE

The annual production of fishes (2001-2002) of the Sirpur Lake was obtained from the local fisherman during harvesting season and data were collected by the Fishery Department Indore. The percentage composition of different fish species is given in tables 1 and 2.

Table 1 : Annual Production of Fish in Sirpur Lake (Indore, India)

Year	Annual Catch	Productivity per acre	Water extent
2001	2035 kg	303.7 kg	6.7 Acres
2002	2250 kg	335.8 kg	

Table 2 : Table Showing Total Fish Catch Composition in 2001 and 2002 of Sirpur Lake (Indore, India)

S.No.	Type of fish	Percentage (%)		Total yield kg	
		2001	2002	2001	2002
1.	Carps	46.5	50.5	947	1136
2.	Live fishes	35.3	33.3	719	749
3.	Eels	0.8	0.7	17	16
4.	Cat fishes	1.8	1.6	35	36
5.	Other fishes	15.6	13.9	317	313

RESULTS

The observation on annual fish production showed that the major population of the lake consisted of carps, live fishes, other fishes showed very meagre representations such as cat fishes, eels and other fishes of low commercial value. The overall production rate cannot be considered satisfactory.

The annual catch composition of fishes (2001-2002) were placed in the Tables 1 and 2. During 2001, the total fish catch was 2035 kg and productivity per acre was 303.7 kg but in the subsequent year (2002), the total fish landing increased to 2250 kg with a productivity of 335.8 kg/acre.

This rise in productivity was mainly due to natural stocking of fingerlings, fry or spawn of fishes. The result also showed that the fish productivity fluctuates from year to year.

Groupwise Catch Composition and Yield of Fishes of the Lake

(A) Carp

Carp stood first in the total catch and was 46.5% and 50.5% of the total fish catch in the years 2001 and 2002 respectively. Among the carp fishes, *Catla catla* dominated. It was 20.2% and 20.3% of the total fish yield in 2001 and 2002 respectively. Its highest catch was recorded in the month of November to March. *Labeo rohita* ranked second (9.2% and 9.8%) in both years (2001 and 2002) with the highest catch in the months of April, May and June. The 3rd position was occupied by *Cirrhinus mrigala* and was 8% in the year 2001 and slightly decreased in the year 2002 (7.8%).

(B) Live Fishes

The live fishes species consisted of *Channa puntatus*, *Channa straiatus, Channa gachua, Anabus testhdineus, Heteropneustes fossilis* and *Clarias batcrachus*. Among the live fishes, *Channa punctatus* was maximum in catch and took the first position of the total yield in both years (12.7% and 12%) respectively with its highest peak catch recorded in the month of October. *Heteropneustes fossilis* took the 2nd position with 10% of the total fish yield in 2001 and 9.5% in 2002.

(C) Eels

This is represented by only *Amphipnous cuchia*. They were present in very few numbers and their percentage was 0.8% and 0.7% in 2001 and 2002 respectively.

(D) Cat Fishes

Cat fishes consisted of *Wallago atlu, Mystus vittatus* and *Mystus tengara*. They were less than 1% in both years of collection (2001 and 2002). Their highest catch was recorded in the month of July.

(E) Other Fishes

The small and low commercial value of fishes is in this group. Among other fishes *Puntius ticto* and *Puntitus sophare* were the dominant species. From the data collected, the average production rate of the Sirpur Lake for the two years (2001 and 2002) was 2142.5 kg. The following were the position of the collected fishes.

(1) *Catla catla* - 1st position.
(2) *Channa punctatus* - 2nd position.
(3) *Labeo rohita* - 3rd position.
(4) *Heteropneustes fossilis* - 4th position.
(5) *Cirrhinus mrigala* - 5th position.

(6) *Channa striatus* - 6^{th} position.
(7) *Labeo gonius* - 7^{th} position.
(8) *Cirrhinus reba* - 8^{th} position.
(9) *Channa gachua* - 9^{th} position.
(10) *Clarias batrachus* - 10^{th} position.

The mixed average population of fishes was 14.7%.

MATHEMATICAL MODEL OF FISH PRODUCTIVITY

We shall make a mathematical model of fish productivity. The generation period is different for different species of fishes (Kapoor, 1995).

First of all we define generation period –

P_n = Populaion of the given species of fish after n generation.

Define change $\Delta P_n = P_n - P_{n-1}$

where, n denotes fixed interval number of intervals when each interval observes a change in the population. Thus interval is called generation.

P_0 - Initial
P_1 - After 1 generation.
P_2 - After 2 generations.
P_3 - After 3 generations.
… … … … …
P_n - After n generations.

$P_n \propto f(P_{n-1})$

$\Delta P_n = B_n f(P_{n-1}) - D_n f(P_{n-1})$

where,

$f(P_n)$ = Fish population of the given species and domain after 'n' generation

B_n and D_n are respective parameters for birth rate and death rate.

It is ideal condition exist for natural births and death without any calamity.

It is also assumed that no other type fishes is interacting with the given one, then,

$P_n = \alpha_n P_{n-1}$, $\alpha_n = 1 + B_n - D_n$ (1)

Eqn.1 is a linear difference equation of first order.

Put, n = 1,2,3,….., n

$P_1 = \alpha_1 P_0$
$P_2 = \alpha_2 P_1 = \alpha_1 \alpha_2 P_0$
$P_3 = \alpha_3 P_2 = \alpha_2 \alpha_3 P_1 = \alpha_1 \alpha_2 \alpha_3 P_0$
$P_4 = \alpha_4 P_3 = \alpha_3 \alpha_4 P_2 = \alpha_2 \alpha_3 \alpha_4 P_1 = \alpha_1 \alpha_2 \alpha_3 \alpha_4 P_0$
… … … … … …

$$P_n = P_0 \prod_{i=1}^{n} \alpha_i$$

Assumption $\alpha_n = \alpha$ then $\alpha = 1 + B - D$

Case I B < D then $\alpha < 1$ (because $\alpha = 1 + B - D$)
For large value of n
P_n – the population of fish is small.

Case II B > D then $\alpha > 1$ (because $\alpha = 1 + B - D$)
For large value of n
P_n – the population of fish is very large.

Case III B = D then $\alpha = 1$ (because $\alpha = 1 + B - D$)
P_n – The population of fish is constant.

RELATION BETWEEN FISH PRODUCTIVITY AND MATHEMATICAL MODEL

The present model suggest that the fish productivity of lake low because its carrying capacity is not fully utilized by present stock of fish in order to increase fish productivity, intensive stocking fish seed is the only alternative to increase fish stock.

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