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Original Article

Impact of Information Technology on Farm Income of Hill Area of India

D. R. Thakur*, Nitika Sood**

Abstract

The study of information technology on farm income of hill area of India during year 2010-11 using simple random sampling technique revealed that mobile service is more common as compared to the other services and cost incurred on this service was one-fourth of the total cost(Rs370/-)of information technology incurred on average farms situation. On an average cost incurred on additional inputs with us the technology for information by the farmers was Rs 1802.50/ farm and added cost to the labor was Rs 895.30/ farm on overall farms situation. Whereas, technology saved time was 10.33 times with one unit used time through information technology. The substantial impact of information technology was noted in enhancing productivity/ production and employment generation. The total contribution of information technology on per farm income was estimated to be Rs 40037 on an average farms situation, which accounted for about 31 percent. The net additional returns over total cost of information technology and additional inputs were Rs 36935.87, accounted for about 28.53 percent of the total farm income. The output-input ratio analysis of the information technology indicated its superiority; it contributes 13 times more with one rupee investment on it.

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Introduction

Today is the era of the Information technology. Information is critical to the social and economic activities that comprise the development process. Economic development has witnessed many revolutions in agriculture (i.e. green, white, yellow and blue revolutions), bio-technology and industries and also in information technology. Good communication and information system reinforce commitment to sustainable productivity in agriculture. It is accepted globally that increased information flow has a positive effect on the agricultural sector. However, collecting and dissemination information is often difficult and costly. Information technology (IT) offers the ability to increase the amount of information provided to all stake holders in the agricultural sector effectively and to decrease the cost of disseminating the information. Hence, it is a well known fact that access to information holds the key for successful development. Improved communication and information access is directly related to socio-economic development of any nation through improving decision-making in agriculture. Agriculture is one of the prospective areas in which information technology is effectively used for the social and economic development of the Indian agrarian community and hill area is no exception.

The economy of Himachal Pradesh, being a hill state, is predominately dependent upon agriculture and in the absence of strong industrial base; any fluctuation in the agriculture and its allied sectors causes serious implications for overall economic growth. Rapid growth of agriculture is essential not only for self reliance, but also for meeting the food

and nutritional security of the hill people thereby bringing about equitable distribution of income and wealth in rural areas to reduce poverty and also improve the quality of life. In agriculture, information technology considered as fifth factor of production along with land, labor, Capital and organization/ management. Information has, therefore, become an important and direct input in agriculture production of hill farmers where roads, transportation means and communication network systems are poor. However, till know no single study has been conducted anywhere to quantify the impact of information technology on agriculture. Whatever studies are conducted those are qualitative in nature. Moreover, the existing information system is beset, with number of problems particularly in hill and rural areas. Therefore, it needs to be investigated through a comprehensive study to assess the impact of information technology on production/income and possible measures for sustainable development of hill agriculture. Keeping this background in view, the present study has been undertaken to assess the impact of information technology on farm income of hill area of India with the following specific objectives

Objective of the study

- To examine sources of information technology used in farm production in the study area.
- To assess the impact of information technology on cost, time, employment, production and income of the farmers.
- To suggest suitable policy measures on information technology for agricultural development.

Methodology

The study was confined to Kangra district of Himachal Pradesh which has maximum number of land holdings (about 22 per cent) and cultivated area (about 21 per cent) of the State. Moreover, State Agricultural University is also situated in this district and lies in the proximity of agricultural advanced state of Punjab. Therefore, information technology could play a catalytic role in agricultural development in this district. Keeping in view, time and resource constraint of the scholar two blocks i.e. one most developed (Panchrukhi) and other most backward block (Nagrota Surian) were selected purposely on the basis of Composite Infrastructural Index (Kumar *et al*. 2007)). In first stage a list of villages falling in each block was prepared from the revenue records and two villages were selected from each block by simple random sampling method. At the second stage, complete lists of farmers were prepared from each selected village and 20 households were selected randomly from each village randomly. Thus, a total of 80 farm households were selected from these two blocks of the district. The study was based mainly on Primary data which were collected through survey method for the year 2010-11. In order to achieve the objectives of the present study, both tabular and mathematical techniques were employed for the analysis and interpretation of the data.

Result and Discussion

Sources of information technology in agriculture

Farming community is facing a multitude of problems to maximize crop productivity. In spite of successful research on new agricultural practices concerning crop cultivation, the majority of farmers are not getting upper bound yield due to several reasons. One of the reasons is that expert/scientific advice regarding crop cultivation is not reaching to farming community timely. It is true that Indian farmers possess a valuable agricultural knowledge and expertise. However, a wide information gap exists between the research level and practice. Farmers need timely expert advice to make them more productive and competitive especially in hill area like Himachal Pradesh where personal mobility is difficult. In order to achieve this objective to some extent, farmers are using different means of information technology. The main sources of information technology used in study area are given in Table 1. In study area mobiles, landlines' phone, television, radio, computer/ internet, e-mail, fax, newspapers and magazines were some sources used by the farmers. It can be seen from the table that in Panchrukhi block total cost involved in the use of information technology per household for agricultural related work was about Rs. 416 whereas in Nagrota Surian block it was Rs. 324 per household. On an overall situation, it was about Rs. 370 per household. It was found that the use of information technology services was higher in advanced area as compared to the backward area in the district. It is evident from the table that more than one-fourth cost was incurred in the mobile services in all the situations in the study area. It indicates that mobile service is more common as compared to the other sources. The rank-wise cost and effectiveness of the sources indicated that in

Table 1: Sources of Information technology on sample households (Annum/ household/)

Particulars	Panchrukhi		Nagrota Surian		Overall	
	Cost (Rs)	Rank	Cost (Rs)	Rank	Cost (Rs)	Rank
Mobile	122.9	1	88.3	1	105.6	1
Landline	72.3	2	44.2	4	58.3	3
Television	64.1	3	64.6	2	64.3	2
Radio	46.7	5	49.4	3	47.9	4
Computer/ internet	3.9	8	-	-	2.0	9
E-mail	8.0	7	5.0	8	6.5	8
Fax	-	-	35.0	5	17.5	7
Newspaper	37.6	6	25.0	6	31.3	6
Magazines	60.3	4	12.5	7	36.4	5
Total	415.7		324.0		369.9	

Panchrukhi area, mobile service was ranked at 1st position followed by landline, television, magazines, radio, newspaper, e-mail and computer/internet. No fax machine service was used by the farmers.

Whereas in Nagrota Surian, mobile services (1st rank) was followed by television, radio, landlines, fax, newspaper, magazines and e-mail. No computer/ internet services were recorded for agricultural information dissemination. In overall situation, mobile ranked at number one television, landlines, radio, magazines, newspapers, fax, e-mail and computer/ internet ranked 2nd, 3rd, 4th, 5th, 6th, 7th, 8th and 9th on the basis of cost per farm respectively in the study area. From the above discussion, it may be inferred that a majority of the respondents were getting agricultural related information through mobiles, television, landlines and radio. The study conducted by Muhammad and Muhammad (2006) in Pakistan on role of mass media in the dissemination of agriculture technologies among farmers reported television at 1st and 2nd position whereas no role of mobile and landline/telephones was noticed.

The farmers of the study area spent more than three-forth of the total expenditure on information technology services for these sources. Some of the farmers used newspapers and magazines for detail information regarding farming and accounted for about one-fifth of the total cost of the information technology services. It was observed during the survey that a vast majority of the respondents did not use internet, e-mail and fax services for getting farming related information and had spent very meager amount, constituted only about 6 per cent of the total cost on information technology services in farming.

Cost of inputs added through information technology

Information technology acts as a catalytic agent in the agricultural production. With the use of technology for information some suggestions and ideas come out to add additional inputs which persuade the farmers for adding additional inputs on their field. These additional inputs incurred some cost. These costs have been presented in Table.2.

Table 2: Cost of critical inputs added through information technology on sample farms (per household)

Sr. No.	Particulars/Inputs	Panchrukhi		Nagrota Surian		Overall	
		Qty	Cost (Rs)	Qty	Cost (Rs)	Qty	Cost (Rs)
1.	Seed treatment (fungicide used) Bavistin,Mavistin (gms)	9.70	3.30	6.50	2.20	8.10	2.75
2.	Chemical weeding (Weedicide used) Himagrilon (kg/lt)	0.80	480.00	0.70	420.00	0.75	450.00
3.	Plant protection (Insecticides, pesticides and fungicides used) Endosulphan,Shri ram Buto 50,Superhit, Tilt, Malathion, Metamil, etc.(kg/lt/gm)	2.02	445.50	0.84	160.00	1.43	302.75
4.	Purchase of FYM (quintal)	23.50	940.00	20.10	804.00	21.80	872.00
5.	Purchase of fertilizers: Urea, IFFCO CAN(kg)	20.00	200.00	15.00	150.00	17.50	175.00
6	Total		2068.80		1536.20		1802.50

It can be seen from the table that additional inputs added in the existing farm situation by the farmers with the use of information technology were seed treatment (fungicide), chemical weeding (herbicide), plant-protection (insecticides), pesticides (fungicides), FYM and fertilizers. These additional inputs add additional cost on the sample farms with additional information along with facilities available through access of information technology. It was found that the total per farm expenditure on various additional farm inputs was more in Panchrukhi (Rs. 2,068.80 / farm) than that of Nagrota Surian (Rs. 1, 536.20 / farm). On overall farm situation, this cost was Rs. 1,802.50 per farm. FYM was found to be the most important input accounting for 48.38 per cent (Rs. 872 / farm) of the total expenditure incurred on additional inputs followed by weeding (24.96%), plant protection measures (16.79 %), fertilizers (9.70%) and fungicide for seed treatment. Similar trend has been observed in Panchrukhi and Nagrota Surian. Thereby, it revealed that the behavior and attitude of the backward and forward farmers in the study area were almost same toward the purchase of additional inputs with the access of information technology.

Impact of information technology on employment

Modern farming is influenced by information technology. It has been observed that technology eliminated many jobs into one and resulted into generation of new type of employment. The efficiency and performance of new jobs depend upon the skills and level required to perform jobs through information technology. It either increases or decreases the employment. In farming, it has been generally observed that information technology has saved the time to get information. After getting sufficient relevant information related to farming, it enforces the farmers to invest more on critical inputs which requires manpower resultantly it influence the employment pattern of the farming system.

The extent of these changes needs to be measured in a quantitative form. Keeping this background in view the employment pattern of the study area was examined and presented in the following sections.

Impact of information technology on time saving and employment.

Information technology helps in place utility of the inputs required by the farmers. Farming related information must be made available in time. For this purpose, a speedy transmission is necessary. Late dissemination of activity-wise information is of no use. Often, this information becomes stale, particularly when it is disseminated too late to be of any use. There were different sources of information technology in the study area which helped the farmers in timely dissemination of the information and saved time of farm labor. It can be seen from Table 3 that information technology saved the time to get information and message relating to farming operations and decisions. In Panchrukhi block total time taken by per farm through information technology related to seed treatment, method of sowing, fertilizer application, irrigation, chemical weeding, plant protection measures, purchase of FYM and fertilizer was 3.1 man hours which had saved 3.3 man days per farm. The time taken to operate all the farming operations in Nagrota Surian was 1.7 man hours per farm and saved time (2.9 man days).

On overall farm situations, per farm time used through information technology was 2.4 man hours and saved the time of 3.1 man days per farm. The operation-wise time used on seed treatment, method of sowing time, fertilizer application, irrigation, chemical weeding, plant protection, purchase of FYM and purchase of fertilizers was 0.4, 0.3, 0.2, 0.3, 0.3, 0.2, 0.2, 0.2 and 0.3 man hours respectively. The situation-wise analysis of the impact of information technology to save time on farm employment indicated that in Panchrukhi information technology saved time of nine hours with the use of one hour to get information through information technology. Whereas time saved 13.65 times in Nagrota Surian with one unit used through information technology. On an average farm situation, time saved was 10.33 times with one unit used time through information technology. The significantly higher time saved with the one unit through information technology has more utility in backward area as compared to the forward area of the district.

Additional employment through information technology

Human labor is a basic input used in production of all agricultural crops. With the support of information technology, the labor used for getting information pertaining to different farming operations had been reduced as on one side presented in Table 3. On the another side, information technology enforced the farmers to add additional inputs which need additional inputs along with human labor on their farm as presented in Table 4.

Table 3: Impact of Information technology on time saving and farm employment (Per household)

Sr. No.	Particulars	Panchrukhi		Nagrota Surian		Overall	
		Used time (Man hours)	Saved time (Man days)	Used time (Man hours)	Saved time (man days)	Used time (Man hours)	Saved time (man days)
1.	Seed treatment	0.4	0.6	0.4	0.8	0.4	0.7
2.	Method of sowing	0.3	0.5	0.3	0.5	0.3	0.5
3.	Sowing time	0.2	0.4	0.2	0.4	0.2	0.4
4.	Fertilizer application	0.5	0.4	0.1	0.2	0.3	0.3
5.	Irrigation	0.4	0.3	0.2	0.1	0.3	0.2
6.	Chemical weeding	0.3	0.2	0.1	0.2	0.2	0.2
7.	Plant protection	0.3	0.4	0.1	0.2	0.2	0.3
8.	Purchase of FYM	0.3	0.2	0.1	0.2	0.2	0.2
9.	Purchase of fertilizers	0.4	0.3	0.2	0.3	0.3	0.3
10.	Total	3.1	3.3	1.7	2.9	2.4	3.1
11	Saved time	8.52 times		13.65 times		10.33 times	

Note: One Manday= 8 hrs man labor

Table 4: Additional employment through information technology for applying additional inputs

(Per household)

Sr. No.	Operations	Panchrukhi		Nagrota Surian		Overall	
		Man days	Value (Rs)	Man days	Value (Rs)	Man days	Value (Rs)
1.	Seed treatment	0.13	15.60	0.10	10.00	0.12	12.80
2.	Method of sowing	4.14	496.80	3.18	318	3.66	407.40
3.	Fertilizer application	0.56	67.20	0.44	44.00	0.50	55.60
4.	Irrigation	2.00	240.00	1.50	150.00	1.75	195.00
5.	Chemical weeding	0.24	28.80	0.18	18.00	0.21	23.40
6.	Plant protection	0.50	60.00	0.44	44.00	0.47	52.00
7.	Application of FYM	1.00	120.00	0.92	92.00	0.96	106.00
8.	Purchase of fertilizers	0.41	49.20	0.37	37.00	0.39	43.10
9.	Total	8.98	1077.6	7.13	713.0	8.06	895.30

It can be seen from the table that the additional man days used for applying additional inputs through information technology on overall farm situation were 0.12, 3.66, 0.50, 1.75, 0.21, 0.47, 0.96 and 0.39 man days per farm on seed treatment, method of sowing, fertilizer application, irrigation, chemical weeding, plant protection measures, FYM carrying/ application and purchase/carrying of fertilizer.

Slightly higher additional labor was observed in all the farm operations in Panchrukhi as compared to Nagrota Surian but, trend was same in all the situations. The total addition labour used in Panchrukhi block was 8.98 man days per farm and the corresponding figure for Nagrota Surian was 7.13 mandays per farm. On an overall farms situation, per farm additional labor used with the support of information technology was 8.06 man days. A critical analysis of the table revealed that with the marginal saving of time (Table 3) through information technology generated additional employment in farming. The addition to cost of the added labor was noted to be Rs 1077.60, Rs 713 and Rs 895.30 per farm in Panchrukhi, Nagrota Surian and overall farms situation in the study area respectively.

Contribution of information technology on farm production and productivity

Information technology brings improvement in farm operations and planning which improves farm production and productivity. The foremost visible impact was increase in output per unit area. It was visualized from Table 5 that the production of major field crops showed increase, which was observed 41 per cent in paddy followed by wheat (35%) and maize (29%) in Panchrukhi (Forward area).

Table 5: Contribution of information technology on existing farm production (Per farm)

Sr. No.	Crops	Panchrukhi		Nagrota Surian		Overall	
		Existing produc Tion (q)	Contrib ution of IT (%)	Existing produ ction (q)	Contri bution of IT (%)	Existing produ Ction (q)	Contrib ution of IT (%)
1	Maize	0.22	29.00	0.24	30.00	0.23	29.60
2	Paddy	24.50	41.00	4.06	27.50	14.28	34.30
3	Wheat	36.00	35.00	26.00	32.50	31.00	33.70
4	Pulses/mash	-	-	1.00	23.00	0.50	23.00
5	Vegetables	1.55	36.50	22.35	29.00	13.73	32.80
6	Potato	18.00	22.50	-	-	-	22.50
7	Sugarcane	-	-	3.90	17.50	1.95	17.50
8	Berseem	3.00	6.50	5.40	8.00	4.13	7.30
9	Tea	1.50	12.00	-	-	0.75	12.00

Where as in Nagrota Surian, maximum increase was observed in wheat (32.5 %) followed by maize (30 %) and paddy (27.5%). In pulses, significant contribution of information technology was noted in production/ productivity (23%) in Nagrota Surian. The results were inconclusive for Panchrukhi as these crops were missing on sample farms. In vegetables, Table 5 further displayed the impact of information technology on production/ productivity of commercial crops including vegetable, potato, sugarcane and tea. The impact of information was quite discernible on all the situations in vegetables. In Panchrukhi increase was significantly higher (36.5%) as against the Nagrota Surian (29%). However, low impact was visible in case of berseem. This may be due to less emphasis towards forage crops. The potato was the commercial crop of Panchrukhi block and contribution of IT in potato production was recorded 22.5 per cent. The sugarcane was climatically commercial crop of Nagrota Surian and tea was in Panchrukhi. The contribution of information technology was noted 17.5 and 12.0 per cent in the respective crop.

On overall farms situation, highest contribution of information technology in cereals production was noted in paddy (34.3%) followed by wheat (33.7%) and maize (29.6%).

In vegetables the contribution of information technology was 32.8 per cent followed by potato (22.5%), sugarcane (17.5%) and tea (12%). The lowest contribution was noted in production of berseem crop (7.3%). The perusal of this table clearly showed substantial impact of information technology in enhancing productivity and production of all crops in the districts.

Contribution of information technology on farm income

The overall impact of information technology on land productivity has been summarized through Table 6. As seen earlier, the information technology spread in all the situations in study area has resulted into increased yield of crops. As such, per farm production increased significantly across all the areas of the district. This increased production ultimately led to increased income per farm. Table 6 indicated that the crop-wise contribution of information technology on farm income ranged from 41 per cent in Paddy to 6.5 per cent in berseem in Panchrukhi. Whereas, in Nagrota Surian highest increase was noted in wheat crop (32 %) and lowest in berseem (8.0%).

On overall farm situation crop-wise contribution of information technology indicated that the highest contribution of information technology was noted in paddy (34.3%) followed by wheat (33.70 %), vegetables (32.8%), maize (29.5%), pulses/mash (23%), potato (22.5%), sugarcane (17.5%), tea (12.0%), and berseem (7.3%).

Table 6: Contribution of Information technology on farm income of sample households (Per farm)

Sr. No	Crops	Panchrukhi			Nagrota Surian			Overall		
		Total income (Rs)	Contribution of IT (Rs)	% contribution of IT on total income	Total income (Rs)	Contribution of IT(Rs)	% contribution of IT on total income	Total income (Rs)	Contribution of IT (Rs)	% contribution of IT on total income
1.	Maize	343	99.47	29.0	494	148.20	30.0	418.5	123.45	29.5
2.	Paddy	47775	19587.75	41.0	5765	1585.38	27.5	26770.0	9182.11	34.3
3.	Wheat	61200	21420.00	35.0	45760	14872.00	32.5	53480.0	18022.76	33.7
4.	Pulses/mash	-	-	-	7500	1725.00	23.0	3750.0	862.50	23.0
5.	Vegetables	2195	801.18	36.5	50800	14732.00	29.0	26497.5	8691.18	32.8
6.	Potato	18000	4050.00	22.5	-		-	9000.0	2025.00	22.5
7.	Sugarcane	-	-	-	1560	273.00	17.5	780.0	136.50	17.5
8.	Berseem	900	58.50	6.5	1674	87.86	8.0	1287.0	93.95	7.3
9.	Tea	15000	1800.00	12.0	-	-	-	7500.0	900.00	12.0
10.	Total	145413	47816.9	32.88	113553	33423.44	29.43	129483	40037.45	30.92

The total contribution of information technology on per farm income was estimated Rs. 47,817 in Panchrukhi, Rs 33,423 in Nagrota Surian and Rs. 40,037 on an overall farms situation, which accounted for about 33, 29 and 31 per cent respectively.

Thus, it can be concluded from the table that information technology is the most important input to increase the farm income in all type of farm situations. Similar results had been obtained by Rheingold (2005) in a study conducted in china about phones and market mobile technology in rural development. He indicated that farms could earn 60 per cent more on their crops if they had access to telephone to learn the true prices in nearby urban markets.

Net income of information technology

Net contribution of information technology indicates the output/return of the information technology on the farm economy. The computation of all costs involved through information technology access on the farm is necessary to determine the real profit of information technology. The cost incurred on different inputs and actual charges of the information technology in the study area has been computed and presented in Table 7. It is evident from the table that the addition human labor cost added for additional inputs with the access of information technology was around Rs. 1,078, Rs. 713 and Rs. 895 per farm in Panchrukhi, Nagrota Surian and overall farm situations respectively. The human labour cost with the access of information technology through time consumption was around Rs. 46.5,

Rs. 21.25 and Rs. 33.88 per farm in Panchrukhi, Nagrota Surian and on an average farms situation respectively. Total addition cost of human labour was around Rs. 1,124.10, Rs. 734.25 and Rs. 929.18 per farm in Panchrukhi, Nagrota Surian and on an average farms situation respectively. Cost of additional critical inputs was also, noted higher in Panchrukhi (Rs 2, 068.80 per farm), as compared to Nagrota Surian (Rs. 1, 536.20 per farm). On an average farms situation the cost of additional critical inputs with access of information technology was Rs. 1,802.50 per farm. The higher net additional costs of human labor and critical inputs in Panchrukhi area indicated that the farmers of forward area were more conscious about new technology and inputs than the backward area of the study area. Cost of information technology charges were around Rs. 416, Rs. 324 and Rs. 370 in Panchrukhi, Nagrota Surian and overall farm situations in the study area, respectively. It revealed that the farmers of advanced area were more aware about the use of farm information technology as compared to the backward area. The total additional cost with the access of information technology was higher in Panchrukhi area (Rs. 3,608.60/ farm) as against the Nagrota Surian (Rs. 2,594.45/farm). On overall farm situation per farm cost was Rs. 3,101.58.The net additional returns over total cost of information technology and additional inputs were Rs. 44,208.30, 30828.99 and 36935.87 per farm in Panchrukhi, Nagrota Surian and overall farm situations respectively. Net contribution of information technology in total farm income was 30.40, 27.15 and 28.53 per cent in Panchrukhi, Nagrota Surian and overall farms situation respectively. The output-input ratio analysis of the information technology indicated its superiority, it contributes 13 times more with per rupee cost. As with the investment of one rupee on information through technology, it will return around Rs. 13 per farm on all the farm situations of the study area. Therefore, information technology enhancement should be adopted as a major policy.

Table 7: Net contribution of the information technology (IT) on sample farms (Rs/farm)

Sr. No.	Particulars	Panchrukhi	Nagrota Surian	Overall
1.	Gross farm income	145413.00	113553.00	129483.00
2.	IT Contribution on gross farm income	47816.90	33423.44	40037.45
3.	Cost addition through IT			
3.1	Additional human labour cost to use critical inputs	1077.60	713.00	895.30
3.2	Human labour cost through IT use	46.50	21.25	33.88
3.3	Total additional cost of human labour (3.1+3.2)	1124.10	734.25	929.18
3.4	Cost of addition of critical inputs on farm	2068.80	1536.20	1802.50
3.5	Cost of information technological sources	415.70	324.00	369.90
4.	Total additional costs (3.3+3.4+3.5)	3608.60	2594.45	3101.58
5.	Net additional income through IT	44208.30	30828.99	36935.87
6.	Net per cent contribution in total income through IT	30.40	27.15	28.53
7.	Out- input ratio (sr.no.2/4)	13.25	12.88	12.91

Suggestion and policy Implications

Majority of the respondents in advanced and backward areas of the state (H.P.) were getting agricultural related information through mobiles, television, landlines and radio which accounted more than three-fourth of the total expenditure on information technology. Whereas vast majority of the respondents did not use internet and email services, accounted only about 6 per cent of the total cost on information technology (IT) services in farming. Therefore, to increase the use of these facilities the state Government should provide subsidy to the farmers. The significantly higher time saved with the one unit through information technology has more utility in backward area as compared to forward area in the study area. Therefore it is suggested that there is a need of deep penetration of information system like mobile phones and other facilities through joint venture with the private sector, NGO and government to enrich information technological system in terms of both hardware and software and the relevant content creation relating to farming support in rural area.

A critical analysis of the results revealed that with the marginal saving of time through information

technology generated additional employment in farming. The addition was higher in forward area (Panchrukhi block) as compared to backward area (Nagrota Surian block). This, calls for taking necessary steps to provide easy cases of information technological knowledge to the farmers through rural information clinics or rural Internet *chaupals* by the enthusiastic young entrepreneurs well trained information communication technology agents, SAUs, and ICAR Institutes located in the study area in particular and state/ country in general.

Contribution of information technology on farm production and productivity showed substantial impact of information technology in enhancing productivity and production of all crops in the study area. Net contribution of IT in the total farm income was 30.40, 27.15 and 28.53 percent in Panchrukhi, Nagrota Surian and overall farm situations respectively.

The out- input ratio analysis of the IT indicated its superiority, it contribute 13 times more with per rupee cost on farming. As with the investment of one rupee on information through IT, it will return Rs. 13 per farm on all the farm situations of the study area. Therefore, information technology enhancement should be adopted as a major policy for the agricultural development in hill area of the state and country.

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Original Article

Diversity of Finfishes and Commercially Important Species in the River Ganga in and around Patna Region

Syed Shabih Hassan*, R. K. Sinha**

Abstract

The River Ganga harbors variety of finfish species including other fauna and flora. It has become a great nutritive value and indicator of ecological condition of river ecosystem which provides sustenance and meet protein requirement to local fishermen as well as other riparian population. The commercial and subsistence fishing activities are in practice by local fishermen using various types of nets, gears and tackles viz., gill nets of varying mesh sizes, large and small drag net, cast net, lift net, dip net, scoop net, plunge basket trap, hooks and long lines in and around Patna region. Most of the fishermen used sturdy plank built boat for the operation of variety of gill nets, drag nets and cast net, long lines, scoop net, and plunge basket trap. The local fishermen also exploit temporarily formed water bodies of the River Ganga to catch existing fishes during non-flood season. Variety of finfish species were monitored from the bulk of fisher catch during many visits at ten landing sites in and around Patna region. A total of 106 finfish species were identified from the bulk of catches belonging to 67 genera, 28 families and 9 orders. A single cartilaginous fish *(Hypolophussephen)* was recorded during flood season while most of the fish were bony skeleton which include 2 feather backs, 4 shads, 2 anchovies, 4 Indian major caprs, 8 barbs, 17 other carps and minnows, one each mahseer, Indian trout, latia fish, Pungas catfish, air breathing catfish, stinging catfish, angler fish, half beak fish, gar fish, panchax minnow, Gangeticmudeel, mottled nandus, badis fish, goby, climbing perch, 2 garra fish, 3 loaches, 8 bag rid catfish, 4 eurasian catfish, 6 schilbid catfish, 11 sisorid catfish, 3 glass fishes, 2 croakers, 2 mullets, 3 gouramies, 4 murrels, 3 spiny eels, and 2 puffer fish. The fish diversity identified from the river Ganga revealed that water is still suitable for proliferation and survival of different types of fish species.

Keywords: Fish Fauna; Diversity; Commercially Important; River Ganga; Patna

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Introduction

There are 14 different river systems in India each of which has catchment area of about 20,000 sq. km or more, 44 medium rivers having an average catchment area between 2,000 and 20,000 sq. km and innumerable small rivers and desert streams that have drainage of less than 2,000 sq. km. Indian rivers carry a surface runoff of 164.5 million hectare meter (mhm), which is 5.6% of the total runoff flowing in all the river of the world (Sinha, 1997). The river basins cover an extensive areas as floodplain wetlands viz; chaurs, beels, jheels, mauns, kol, dhab, etc. They together form an area of more than 200,000 ha sustaining various types of fishes besides other aquatic fauna.

The River Ganga (2525 km), the lifeline of Indian sub-continent, originates at an altitude of 4100 meters above mean sea level from an ice cave, Gaumukh, near Gangotri in the Himalayas and discharges into the Bay of Bengal. The Ganga basin is the largest river basin in India (861404 sq. km). It drains 8 states namely Uttar Pradesh, Haryana, Delhi, Himachal Pradesh, Rajasthan, Madhya Pradesh, Bihar and West Bengal. The Ganga enters the state of Bihar at Chausa near Buxar and leaves at Rajmahal after

covering a distance of about 550 km. It is a broad meandering river of advanced stage and its plains cover an approximate area of 71,680 sq. km and accounts for about 42% of the surface of state (Ahmad and Singh, 1991). The main tributaries of the Ganga are Ramganga, Yamuna, Tons, Gomti, Ghaghara, Sone, Gandak, Burhi Gandak, Kosi etc. These tributaries account for 60% of the total water of the river. It has one of the densest human populations of the world, about more than 550 people per sq. km. The Ganga-Brahmaputra-Meghna river basins takes up just 0.12% of the World's landmass, it is home to 10% of its population (Patel, 1996).

The freshwater fish fauna of India is quite interesting and offers an exceptional opportunity to study the diversity and their distribution. From the known geographical distribution of genera of primary freshwater fishes, it has been clearly indicated that the fish fauna comprises three categories viz., Indian, Indo-Chinese and Malayan with indigenous Gondwana elements and intrusive genera (Jayaram, 1977). The original fauna has been retained on isolated hill tops of the peninsular India where suitable ecological niches are available. The striking vividity in ecological and morphoedaphic features of the Himalayan and Peninsular drainages has a pronounced bearing on the qualitative and quantitative distribution of fish fauna (Kamal, 1991).

The richness of animal resources of India is largely due to its geographical position and the fact that it possesses all possible kinds of ecosystems within its territorial limits. The ecology of major regions of India is however, largely dependent on rainfall. The area of Indian land territory is only about 2.4% of world's total land masses. India harbors as much as 8% of all known species of animals and plants which stands seventh as far as the number of species contributed to agriculture is concerned (Khoshoo, 1995). There are 74,875 species of animals; out of this 2546 are fishes both marine and freshwater comprising 59.27% and 2.02% of total number of biota respectively (Khoshoo, 1995). Globally fish constitutes almost half of the total number of vertebrates. Nelson (1984) estimated 21,723 living species of fish in the world compared with 21450 extant tetrapods. Earlier about 20,000 species of fishes were estimated, out of which approximately 19,400 were teleosts, nearly 59% marine and 41% freshwater (ZSI, 1991). 2650 fish species were also estimated from the faunal limits of India (ZSI, 1991). The present estimate is, however, 2546 species belonging to 969 genera and 254 families.

The fishery resources of the River Ganga are of tremendous economic and nutritional value. People regard the Gangetic fish as the gift of the Holy Ganga, which has good commercial value as compared to other fish. Hamilton (1822) identified 275 species of fishes from Ganga and its branches and opined that 'the list is far from complete'. The River Ganga at present sustains approximately 2500 species of biota including microorganisms to mammals. Various developmental and anthropogenic activities, such as irrigation hydro-electric project, flood control measures, water abstraction, domestic discharge, disposal of waste water and garbage, cloth washing, bathing, cattle wallowing, defecation, navigation, oil spilling, disgorging of animal carcasses and partly burnt human cadaver, cremation, recreation and trade for the community living etc are going on along the bank of the Ganga. Such activities are increasing day by day and adversely affecting the riverine biota as well as the pristine purity of the river water. Despite all activities, a report indicated that 375 species of fish are still surviving in the River Ganga (Talwar, 1991). Out of this 17 species are threatened and 4 have become endangered. Many of these viz; sting ray, featherbacks, hilsa, shads, herrings, anchovies, Indian major carps, minor carps, large and small catfishes, croacker, mullets, murrels, live fishes, spiny eels, shrimps and prawns are of varying commercial importance. The exploitation of these natural resources is being carried out exclusively by the local fishing community, an economically poor section of the society, through traditional techniques. The Ganga fishery supports a sizeable number of riparian fishermen all along its course. The variety and the extent of riverine catch from the River Ganga used to be considerable in the past but in the last few decades due to increasing anthropogenic stresses including developmental activities in the Ganga basin, the ecology of river in general and fishery in particular have adversely been affected. It has changed the stock dynamics, species diversity, and catch weight composition. The incidence of fish killing due to pollution which in turn emerge in the form of diseases like epizootic ulcerative syndrome, dropsy, fin rot, and asphyxiation among ichthyofauna (Das, 1997).

Methodology

The city of Patna (25° 37' N; 85° 21' E) is situated 53 meters above mean sea level (MSL) along the southern bank of the River Ganga. The stretch of the

River Ganga at Patna is 22 km from upstream Digha to downstream Malsalami. The fish diversity of the River Ganga, its monitoring, survey and evaluation were undertaken by systematic planning which involves strategic sampling and analyses. The frequency of the survey, monitoring and schedules of sampling, keeping in view with fishing operation at landing sites, catch composition, pollution load and the hydrological aspects of the river through proper designing. It was carried out with proper accuracy to avoid any error. During the present investigation, the data of finfish diversity and fisheries at each landing site were collected between 5.30 to 9.30 am taking all the necessary precautions. The landing site I to X were selected for weekly survey. Fresh fish samples were collected from the River Ganga at landing sites and immediately brought in the laboratory for identification of species with the help of standard keys and diagnostic characters such as morphometric, meristic and descriptive features of each species following Day (1878), Hora (1927, 1930), Menon (1974), Srivastava (1980), Talwar and Jhingran (1991) and Jayaram (1977 and 1999).

Results and Discussion

Fish Stock Resources and Species Diversity

Fishes available in the River Ganga and its adjoining floodplains in and around Patna with their common names and names in local parlance was closely monitored and finfish species were identified with the help of standard keys and distinguishing characters. The systematic positions of all identified fishes have been given in Table-1. A total of 106 species of finfish and two species of crustacean (Prawn and shrimp) have been recorded from the River Ganga during the present study. Besides identification of fish species, five different fish habitats and breeding grounds were also identified in the River Ganga in and around Patna. These habitats are the main channel of the river, the adjoining floodplains and three types of temporary lentic water bodies usually formed in the floodplains which are either connected with the main channel or remains separated for few months. Such lentic water bodies are called "Kol", "Dhab" and "Maon" in local parlance. "Kol" remains connected with the river channel whereas the others are not. Out of 106 species recorded, 81 species were from "Kol", 45 from "Dhab" and 27 from "Maon". Many species were found to be present in all such water bodies. The main channel of the River Ganga was found to harbour all 106 species. All these fish species were caught by varieties of indigenous, non-mechanized boats which were used for operating the larger nets in high as well as low water currents in the Ganga river system in and around Patna region. Small riverine and estuarine crafts known as 'Dinghis' or 'Nao' are extensively employed. Nevertheless, with the advancement of technical know-how and ideas, certain gears are used more frequently. By and large, the cotton and jute nets have been replaced by nylon nets. Fishermen use a series of gears when water level starts increasing or when flood starts receding. Generally, static, filtering, plunge basket trapping and long- lining gears are used during the period because fish migrates either towards floodplains or back for the purposes of feeding or breeding. During monsoon period, some of the nets like shooting nets are used for the collection of spawn while other nets for fry, fingerlings and brooders. Application of bamboo reeds and strips for forming barriers across the width of narrow channels are also common. Various gill nets, longlines, plunge basket traps or individual fish traps are dominantly used during high water period. Long fences containing several small cages are used to catch the fish into one central holding chamber. Drag nets/seine nets, large meshed gill nets, shallop with white screen, purse net, scoop net are used during dry season. Large mesh sized gill net is used usually in the middle stretch of the river in order to catch big size fish during dry season. Hilsa and Indian major carps of commercial value are caught by purse net and gill nets having varied mesh sizes. All these traditional gears are helpful in sampling of variety of finfish species from the river Ganga and also source of livelihood for fishermen community.

A single cartilaginous fish, *Hypolophussephen,* was recorded from the Ganga at Patna that too only once during flood season. Most of the species were recorded bony skeleton which includes feather back (2 species), shads (4 species), anchovies (2 species), Indian major carps (4 species), barbs (8 species), other carps and minnows (17 species), mahaseer (1 species), Indian trout (1 species), latia fish (1 species), garra fish (2 species), loaches (3 species), bagrid catfish (8 species), Eurasian catfish (4 species), schilbid catfish (6 species), pungas catfish (1 species), sisorid catfish (11 species), airbreathing catfish (1 species), air sac/stinging catfish (1 species), square head or angler fish (1 species), half beak fish (1 species), gar fish (1 species), panchax minnow (1 species), Gangetic mud eel (1 species), glass fishes (3 species), croakers (2 species), mottled nandus (1 species), badis fish (1 species), mullets (2 species),

gobie (1 species), climbing perch (1 species), gouramies (3 species), snakeheads or murrels (4 species), spiny eels (3 species) and puffer fish (2 species). A total of 106 fish species the catch data of 69 finfish and 2 crustacean species have been recorded during the present study. However, 45 species were found to be commercially more important. Cyprinids were found to be largest contributor at all the landing site.

The declining trend of commercial fishes in the River Ganga in recent past is a matter of great concern and is a big challenge for the fishery scientist. In recent past the fish diversity has attracted the attention of diverse group of biologists including ichthyologists and taxonomists because of the increasing demand of protein requirement, sustained land food production, conservation and management of inland natural resources. Ichthyofaunal resources and species diversity are known to be influenced by various factors affecting ecosystem as well as fishermen. The contribution of some of the ichthyologists such as Hickley and Starkie (1985) who studied on the cost effective sampling of fish populations in large water bodies. Jhingran and Gupta (1987) studied on the reappraisal of the fisheries ecology of the Ganga river system. Natrajan (1989) reviewed the environmental impact of Ganga basin development on gene pool and fisheries of the Ganga River system. Jhingran (1991) described challenging frontiers in freshwater fisheries. Kamal (1991) studied on the riverine fisheries in India-a retrospect. Ahmad and Singh (1991) studied on the river systems of Bihar: Scope, prospects, potentialities and conservation of capture fisheries. Mondal and Gupta (1992) studied on the fish population dynamics and their role in resource assessment.

Fish catch its catch composition and commercial value

Besides enumeration and identification of fish species from different habitats, the catch composition were also recorded during the present study at ten different landing sites species-wise contribution of 71species including 2 species of crustaceans and their month-wise, season-wise occurrence and diversity were recorded. It was found that *Clupisomagarua* contributed maximum (14.68%) of total catch followed by *Aspido pariamorar*(10.56%) and *Setipinnasps.* (7.04%). The classification based on major habitat preference and food habits have also evaluated. The contribution of 14 species was observed to be more than 2 percent in over all catch from the River Ganga. The size of individual fish species and their respective commercial values in local markets were recorded. It was interesting to note that commercial value of fishes varied according to freshness, size, species and season. The least available fishes were more costly as for example prawns, hilsa, Indian major carp, mahaseer, butter fish, ailia, batchawa, patasi, silond, pungas, goonchh, rita, magur, singhi, spiny eel etc. However, mahseer was rarest of rare catch and whenever, it was caught; its selling price was rupees 150 per kilogram. Larger carps and hilsa were sold at rupees 120 to 200 per kilogram whereas rate of most of the catfishes varied from rupees 100 to 250 per kilogram depending upon size and quality. The commercial values of some of the smaller species *(Ailiacoila*and *Pseudeutropiusatherinoids)* were found to be quite high as they were in good demand. Interestingly, it was observed that riverine fish or Gangetic fish have more commercial value as compared to cultured fish in and around Patna.

Fish species diversity and commercial importance

The Ganga River system harbours a rich diversity of Ichthyofauna. Menon (1974) listed 141 species occurring in the Ganga river system belonging to 72 genera, 30 families and 11 orders. Out of 141 species of finfish, 28 were economically important species. During the present investigation the ichthyofaunal diversity was of 106 species occurring in the river Ganga in and around Patna belonging to 67 genera, 28 families and 9 orders. Out of 106 species 45 were recorded to be commercially important which is liked by the consumer in Patna locality. The warm water lotic species of economic importance are the major carps (*Catlacatla, cirrhinusmrigala, Labeorohita*and *L. calbasu*) and the large catfishes *Mystusaor, M. seenghala, Rita rita, Wallagoattu, Siloniasilondia, Pangasiuspangasius* and *Bagarius-bagarius* as reported by Natrajan, 1989. Besides these *Notopteruschitala, Channamarulius* and species found in marshy habitats include *Clariasbatrachus, Heteropneustes fossilis, Channa* sps; *Amphipnouscuchia, Anabas testudineus, Mastacembelus* sps, *Notopterus notopterus* and *Gudusia chapra* are economically important fish. The anadromoushilsa fetches approximately rupees 500 to 800 per kilogram. Hilsa species recognized as of great commercial importance in eastern part of India (West Bengal, Assam, Bihar, Arunachal Pradesh) including eastern part of Uttar Pradesh and Bangladesh.

Talwar (1991) listed 375 species of fish from the entire Ganga river. National Bureau of Fish Genetic Resources in its annual report 1996-97 has reported 382 species from Ganga river system out of which 111 are from Uttar Pradesh and Bihar. Under the present investigation in a small stretch of 30 km of Ganga near Patna, interestingly a total of 106

Table 1: Systematic Position of Fish Fauna in the River Ganga in and around Patna Region

Grade – Pisces
Class – Chondrichthyes
Sub-class- Elasmobranchii
Order- Rajiformes
Suborder – Myliobatidoidei
Family – Dasyatidae
1. *Hypolophussephen (Frosskal)*

Class – Osteichthyes
Sub-class – Actinopterygii
Subdivision – Teleostei
Infradivision – Osteoglossomorpha
Order – Osteoglossiformes
Suborder – Notopteroidei
Family – Notopteridae
2. *Notopterusnotopterus (Pallas)*
3. *Notopteruschitala (Ham.)*

Infra division – Clupeomorpha
Order - Clupeiformes
Family – Clupeidae
Subfamily – Alosinae
4. *Gudusiachapra (Ham.)*
5. *Hilsa (Tenualosa) ilisha (Ham.)*

Subfamily – Dorosomatinae
6. *Gonialosamanmina (Ham.)*
7. *G. modestus (Day)*

Family – Engranulidae
8. *Setipinnabrevifilis (Valen.)*
9. *S. Phasa (Ham.)*

Infradivision – Euteleostei
Order – Cypriniformes
Family – Cyprinidae
Sub-family – Cyprininae
10. *Catlacatla (Ham.)*
11. *Chaguniuschagunio (Ham.)*
12. *Cirrhinusmrigala (Ham.)*
13. *C. reba (Ham.)*
14. *Labeobata (Ham.)*
15. *L. calbasu (Ham.)*
16. *L. gonius (Ham.)*
17. *L. pangusia (Ham.)*
18. *L. rohita (Ham.)*
19. *Osteobramacotiocotio (Ham.)*
20. *Puntiuschola (Ham.)*
21. *P. conchonius (Ham.)*
22. *P. phutunio (Ham.)*
23. *P. saranasarana (Ham.)*

Family – Schilbeidae
Subfamily – Ailiinae
59. *Ailiacoila (Ham.)*

Subfamily – Schilbeinae
60. *Clupisomagarua (Ham.)*
61. *Eutropiichthys murius (Ham.)*
62. *E. vacha (Ham.)*
63. *Pseudeutropius atherinoides (Bloch)*
64. *Siloniasilondia (Ham.)*

Family – Pangasiidae
65. *Pangasiuspangasius (Ham.)*

Family – Sisoridae
66. *Bagariusbagarius (Ham.)*
67. *B. yarrellii (Sykes)*
68. *Eristhistespussilus (Mull. &Tros.)*
69. *Gagatacenia (Ham.)*
70. *G. gagata (Ham.)*
71. *Glyptothoraxtelchitta (Ham.)*
72. *Hara hara (Ham.)*
73. *H. Jerdoni (Day)*
24. *P. sophore (Ham.)*
25. *P. ticto (Ham.)*
26. *Tor tor (Ham.)*

Subfamily – Cultrinae
27. *Chela cachius (Ham.)*
28. *C. laubuca (Ham.)*
29. *Salmostomabacaila (Ham.)*
30. *Securiculagora (Ham.)*

Subfamily – Rasborinae
31. *Amblypharyngodonmicrolepis (Bleeker)*
32. *A. mola (Ham.)*
33. *Aspidopariajaya (Ham.)*
34. *A. morar (Ham.)*
35. *Daniodangila (Ham.)*
36. *Daniodevario (Ham.)*
37. *Esomusdanricus (Ham.)*
38. *Parluciosomadaniconius (Ham.)*
39. *Raimas bola (Ham.)*

Subfamily – Garrinae
40. *Crossocheiluslatiuslatius (Ham.)*
41. *Garragotylagotyla (Gray.)*
42. *Garralamta (Ham.)*

Subfamily – Nmacheilinae
43. *Nemacheilusbotia(Ham.)*

Family – Cobitidae
Subfamily – Cobitinae
44. *Lepidocephalusguntea (Ham.)*

Subfamily – Botiinae
45. *Botiadario (Ham.)*
46. *B. Lohachatachaudhuri*

Order – Siluriformes
Family – Bagridae
47. *Aorichthysaor (Ham.)*
48. *A. seenghala (Sykes)*
49. *Mystusbleekeri (Day)*
50. *M. cavasius (Ham.)*
51. *M. menoda (Ham.)*
52. *M. tengara (Ham.)*
53. *M. vittatus (Bloch)*
54. *Rita rita (Ham.)*

Family – Siluridae
55. *Ompokbimaculatus (Bloch)*
56. *O. pabda (Ham.)*
57. *O. pabo (Ham.)*
58. *Wallagoattu (Schneider)*

85. *Pseudambassisbaculis (Ham.)*
86. *P. ranga (Ham.)*

Family – Sciaenidae
87. *Johniuscoitor (Ham.)*
88. *J. gangeticus (Talwar)*

Family – Nandidae
Subfamily – Nandinae
89. *Nandusnandus (Ham.)*

Sub-family – Badinae
90. *Badisbadis (Ham.)*

Suborder – Mugiloidei
Family – Mugilidae
91. *Rhinomugilcorsula (Ham.)*
92. *Sicamugilcascasia (Ham.)*

Suborder – Gobioidei
Family – Gobiidae
Subfamily – Gobiinae
93. *Glossogobiusgiuris (Ham.)*

Suborder – Anabantoidei

74. *Nangranangra (Ham.)*
75. *N. Viridescens (Ham.)*
76. *Sisorrhabdophorus (Ham.)*

Family – Clariidae

77. *Clarias batrachus (Linnaeus)*

Family – Heteropneustidae

78. *Heteropneustes fossilis (Bloch.)*

Family – Chacidae

79. *Chacachaca (Ham.)*

Order – Cyprinodontiformes
Suborder – Exocoetoidei
Family – Hemiramphidae

80. *Hyporhamphus limbatus (Valen.)*

Family – Belonidae

81. *Xenentodoncancila (Ham.)*

Sub-order – Cyprinodontoidei
Family – Aplocheilidae

82. *Aplocheiluspanchax (Ham.)*

Order – Synbranchiformes
Family – Synbranchidae

83. *Monopterus (Amphipnous) cuchia (Ham.)*

Order – Perciformes
Suborder – Percoidei
Family – Ambassidae

84. *Chanda nama (Ham.)*

Family – Anabantidae

94. *Anabas testudineus (Bloch.)*

Family – Belontiidae
Subfamily – Trichogasterinae

95. *Colisafasciatus (Scheinder)*
96. *C. lalia (Ham.)*
97. *C. sota (Ham.)*

Suborder – Channoidei
Family – Channidae

98. *Channamarulius (Ham.)*
99. *C. orientalis (Bloch & Schneider)*
100. *C. punctatus (Bloch)*
101. *C. striatus (Bloch)*

Suborder – Mastacembeloidei
Family – Mastacembelidae

102. *Macrognathus aral (Bloch & Schneider)*
103. *M. pancalus (Ham.)*
104. *Mastacembelus armatus (Lacepede)*

Order – Tetraodontiformes
Family – Tetraodontidae

105. *Chelonodon fluviatilis (Ham.)*
106. *Tetraodon cutcutia (Ham.)*

species of ichthyofauna has been recorded and identified. Besides the fishes of economic importance listed by Natrajan (1989), Schilbeids (*Eutropiichthysvacha, Clupisomagarua, Ailiacoila* and *Pseudeutropiusatherinoides*), silurids (*Ompokpabda*) were found to be commercially very important. The other economically important species recorded at Patna were *Gonialosamanmina, Setipinnasps, Labeobata, L. gonius, Salmostomabacaila, Aspidopariamorar, A. jaya, Mystuscavasius, M. tengra, Bagariusyarrellii, Nangraviridescence, Xenentodoncancila, Johniuscoitor, Rhinomugilcorsula, Sicamugilcascasia, Channaorientalis, C. punctatus, C. striatus, Macrognathusaral*and *M. pancalus*. In total around 45 species recorded in catches at Patna are commercially important. *Amphipnouscuchia* and *Anabas testudineus*, though categorized as economically important by Natrajan (1989), are not liked by the consumer at Patna. These fishes are economically least important.

Due to human intervention and competing demands for water as a resource, many aquatic species now face a reduction in abundance or even extinction. For many rivers of the world, the abundance and composition of original fish communities has been significantly altered. The combination of both the direct effects of exploitation and the indirect influences of other sectorial activities have had considerable implications for the survival and livelihood of fish and fisheries of most river basins of the world. The intensity of fishing pressures on naturally occurring riverine fish species and stock vary seasonally in the River Ganga with changes in abundances with flood requirement and fish life cycles. The effects of human activities in the Ganges river include altered morphology of river, disturbed flow pattern, eliminated or reduced fish habitat areas, altered species diversity and quality as well as quantity of fish stock, and reduced water quality. Such activities are increasing day by day due to human intervention and increasing population. The future of ichthyofaunal diversity and its well being lies on the responsibility of the aquatic resources exploiter, policy maker and adoption of conservation and management measures including good water quality of the River Ganga so that the stock of threatened, vulnerable, endangered and depleted finfish species may be replenished.

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Original Article

Anti-Lipid Peroxidation Activity of *Acorus Calamus* against Paracetemol induced Hepatotoxicity in Rats

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Abstract

Lipid Peroxidation is an Indicator of Oxidative Damage in the Liver. Upon exposure to the free radicals, the ratio of natural antioxidants in the liver and reactive oxygen species gets altered which results in the production of various lipid peroxyl radicals and hydro peroxides. The extent of lipid peroxidation can be estimated by elevated levels of Malondialdehyde (MDA) in Liver tissue. The present study was designed to screen the anti-lipid peroxidation activity of *Acorus calamus* rhizome extract in paracetamol induced hepatotoxic rat model. Paracetamol at the dose rate of 200 g/kg B.wt was given orally to induce hepatotoxicity and observed the rise in MDA levels. Forty eight hours after paracetamol administration the rats were treated with alcoholic and aqueous extracts of Acorus calamus rhizome for a period of ten days and the liver homogenate levels of MDA was estimated. The treatment of *Acorus calamus* rhizome extract in paracetamol induced hepatotoxic rats normalized the altered MDA levels in liver homogenate which are comparable with Silymarin, a standard hepato-protective drug.

Keywords: Acorus calamus; Lipidperoxidation; Paracetomol; Silymarin; Vitamin-E

Introduction

Lipid peroxidation can be described generally as a process under which oxidants such as free radicals or non-radical species attack lipids containing carbon-carbon double bond(s), especially polyunsaturated fatty acids (PUFAs) that involve hydrogen abstraction from a carbon, with oxygen insertion resulting in lipid peroxyl radicals and hydro peroxides (Yin *et al.,* 2011).

Amongst of all the products produced by lipid peroxidation MDA is one of the most popular and reliable markers that determine oxidative stress in clinical situations (Giera *et al*., 2012).Most of the drugs have the common side effect of producing the hepatic damage through lipid peroxidation. In spite of tremendous strides in modern medicine there is a lack of ideal hepatoprotective drug hence the phytotherapeutic approach to modern drug development has provided numerous plants and poly herbal preparations in the treatment of liver disorders. This is prompting many scientists in medical research to explore the rich flora of India to come out with effective hepatoprotectants.

So the present study was designed to counter the lipid peroxidation produced by the Paracetamol in rats.

Acorus calamus is a semiaquatic perennial aromatic herb with creeping rhizomes belonging to the family Araceae. It is commonly called as vacha, vasa, sweet flag etc. It is commonly used to protect the children from kapha disorders and for the improvement of the intelligence and as memory enhancer. The rhizome powder of *A. calamus* is used in the training

of talking birds. The medicated oil of calamus roots is used externally for massages to relieve vata and kapha disorders (Kulkarni, 1998).

The rhizomes of *A.calamus* possess spasmolytic (Gilani *et al.*,2006), ectoparasiticide, insect repellant (Ghosh *et al.*, 2011), anti-secretagogue, antiulcer and cytoprotective (Rafatullah *et al.*, 1994), antidiarrheal (Gilani *et al.*, 2006), hypolipidemic (Parab and Mengi, 2002), anthelmintic and antibacterial (Gaw *et al.*, 2002), neuroprotective (Pradeep *et al.*, 2002), antioxidant (Ulyana et al., 2002), larvicidal (Suryadevara and Khanam, 2002), bio pesticide (Rani et al., 2003), antiproliferative and immunosuppressive (Mehrotra et al., 2003), anticonvulsant (Yende et al., 2009) and antifungal (Jaripa Begum *et al.*, 2004), properties.

It is also used as an ingredient in polyherbal preparations like Asthamania gritha, Canadian bitters, brahmarasayan etc.

Objectives of the present study

1. To screen the ethanolic and aqueous extracts of rhizome of Acorus calamus for its anti-lipid peroxidation activity.
2. To compare the anti-lipid peroxidation activity of *Acorus calamus* with a standard hepatoprotective drug Silymarin and antioxidant vitamin E.

Materials and Methods

Drugs and Chemicals

Paracetamol complying with the specifications of IP was procured from M/s Granules India Limited, Hyderabad as gratis. Sylimarin was procured from M/s Micro labs, Bangalore as gratis. Vitamin E was procured from Himedia Laboratories Pvt. Limited, Mumbai. Analytical grade chemicals from SD Fine Chemicals Ltd. and SRL Pvt. Ltd., were used in the study. Paracetamol suspension was prepared with 0.5% Carboxy Methyl Cellulose (CMC) in water. Sylimarin was suspended in 0.5% CMC.

Collection of Plant Material

Whole plant of *Acorus calamus* was collected from the local market and surrounding areas of Tirupati, Andhra Pradesh, India. The plant was identified and authenticated by the herbarium specialist, Department of Botany, S.V.University, Tirupati.

Preparation of Alcoholic extract of Acorus calamus rhizome

Acorus calamus rhizomes were dried in shade, later they were powdered and extracted (1.5 kg) successively with 30 liters of 60% alcohol in a soxhalet extractor for 18-20 hours. The extract was distilled and concentrated to dryness under reduced pressure and controlled temperature (40-50^{o}c) and finally freeze-dried. The ethanolic extract yielded a weight of 150 g (10% w/w).

Preparation of Aqueous extract of Acorus calamus rhizome

The dried rhizomes of *Acorus calamus* were powdered and the powdered material was taken in a round bottom flask and was extracted with water for 48 h at room temperature. After 48 h, the solution was concentrated in a rotatory evaporator. Aqueous and alcoholic extract of *Acorus calamus* was suspended in 0.5% CMC.

Collection of organs

Liver pieces were taken and minced into fine pieces and 10% homogenate was prepared with 0.1M Tris–HCl buffer, pH 7.4.The samples were centrifuged in a R-8C centrifuge at 7000 rpm for 15 min and the supernatant was stored at –20^{o}C for further analysis.

Assay of Thiobarbituric acid reactive substance (TBARS) (Yagi, 1984)

To 0.5ml of homogenate, 1ml of 20%TCA and 2 ml of 46 mM TBA reagent were added, mixed well and kept in boiling water bath for 30 min. The test tubes were then cooled and centrifuged at 3000 rpm for 3 min. The supernatant was taken and the color formed was read at 532 nm. Standards of different concentrations (0.1 – 0.5 n moles of MDA) were run simultaneously for getting standard curve. The concentration of test samples was obtained using the standard curve.

Experimental animals

Male albino rats of *wistar* strain weighing 150-200g were obtained from Department of Laboratory Animal Medicine, TANUVAS, Madhavaram milk colony, Chennai. The animals were maintained under standard laboratory conditions with food and water adlibitum. Approval of the experimental

protocol was obtained prior to the conduct of the experiment from the institutional animal ethics and bio-safety committee. The experiment was conducted in Department of Pharmacology and Toxicology, College of Veterinary Science, Tirupati.

Experimental Design

Forty eight rats were assigned randomly to six groups each containing eight rats. Group I received 0.5% Carboxy methyl cellulose *p.o.* for ten days. Animals of Group II to VI received single oral dose of paracetamol @ 2g/kg on Day one. Group III and IV received ethanolic and aqueous extract of *Acorus calamus* rhizome orally forty eight hours post administration with paracetamol for ten days respectively. Group V received Sylimarin @ 25mg/kg orally forty eight hours post administration with paracetamol for ten days. Group VI received vitamin E @ 30 mg/kg orally forty eight hours post administration with paracetamol for ten days.

Twenty four hours after the last day of treatment under ether anesthesia and whole livers were collected after sacrificing the animals by decapitation.

Statistical analysis

The data was subjected to statistical analysis by applying one way ANOVA as per the standard methods of Snedecor and Cochran (1994). Differences between means were tested using Duncan's multiple comparison test and significance was set at P<0.05 and P<0.01.

Results

The mean values of lipid peroxidation in various groups of the present study was presented in Tab.1 and Fig.1

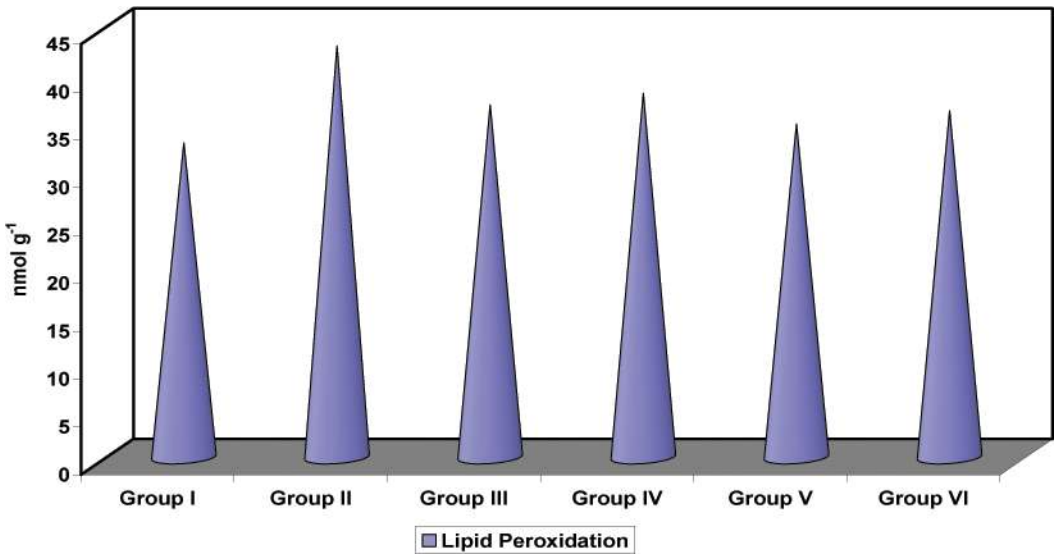
There was significant (P<0.01) elevation of MDA levels in group II to 42.95±0.869 when compared to group I 32.8±0.357. There is no significant differences between group III (36.78±0.41), IV (38.00±0.44) and VI (36.18±0.75) at P<0.01. The values of group III and VI are on par with each other. The values of group I (32.80±0.35) and group V (34.78±0.59) are similar with each other.

Table 1: Effects of alcoholic and aqueous extracts of *A. calamus* rhizome on Lipid peroxidation in hepatic tissue (nM MDA/g tissue)

S.No.	Title	Lipid peroxidation (nmol g^{-1})
1.	Group I	32.80 ± 0.35^{d}
2.	Group II	42.95 ± 0.86^{a}
3.	Group III	36.78 ± 0.41^{b}
4.	Group IV	38.00 ± 0.44^{b}
5.	Group V	34.78 ± 0.59^{c}
6.	Group VI	36.18 ± 0.75^{bc}

One way ANOVA, the values are mean±SE, n=6
Different superscripts a, b, c, d are statistically significant at P < 0.001 and P<0.005

Fig.1



Discussion

Paracetamol (acetaminophen) induced hepatotoxicity is thought to be caused by N-acetyl p benzoquinoneimine (NAPQI), a cytochrome P_{450} mediated intermediate metabolite. NAPQI react with -SH group such as glutathione and protein thiols. The covalent binding of NAPQI to cell proteins is the initial step for cell necrosis (Trimenstein and Nelson, 1990).

Paracetamol, primary cellular targets have been postulated to be mitochondrial proteins with resulting loss of energy production as well as proteins involved in cellular ion control (Nelson, 1990).Oxidative stress is another mechanism postulated to be important in the development of paracetamol toxicity (Bhattacharya *et al*., 2003 and Kumar *et al*., 2005).Lipid peroxidation serves as a marker of oxidative stress. Lipid peroxidation is oxidative deterioration of poly unsaturated lipids and it involves ROS and transition metal ions.It is a molecular mechanism of cell injury leading to generation of peroxides and lipid peroxides, which can be decomposed to yield a wide range of cytotoxin products, most of which are aldehydes such as MDA (Sangeeta *et al.,* 2004).

A substantial increase in hepatic lipid peroxidation was evident by elevated MDA level in liver homogenate of paracetamol administered group which was similar to the findings of Kapur *et al.* (1994), Ahmed and Khater (2001) and Kumar *et al.* (2005). There is a direct correlation between glutathione depletion and lipid peroxidation (Neha and Rawal, 2000). The elevated levels of MDA were suppressed by Silymarin (Bhattacharya *et al.,* 2003).Silymarin reduced the MDA levels in tissue due to its antioxidant activity (Shenoy *et al.,* 2002). Vit.E inhibits the lipid perodixation due to its antioxidant activity (Ayla *et al.,* 2003). *Acorus calamus* reduced the paracetamol induced lipid peroxidation. Manikandan et al. (2005) reported Acorus calamus reduced lipid peroxidation levels in rats exposed to noise induced stress.

In normal cell, a balance exists between oxidative products and antioxidant protection. The intracellular antioxidants GSH, vit. E and vit. C are interrelated with each other and they can be recycled. Recycling of tocopheroxyl radicals to tocopherol is achieved by reaction with ascorbic acid, a major mechanism for maintenance of tissue tocopherol levels (Arivazhagan *et al.,* 2000).

Vit. C deficiency results in depletion of tissue vit. E level vit. C itself acts as a powerful scavenger of superoxide induced lipid peroxidation. Endogenous vit.C levels have been reported to decline under stress conditions (Acharya and Acharya, 1997). The levels of Vit.C and E were increased in the animals treated with á-asarone, one of the active principles present in *Acorus calamus*, which prevented the protein oxidation and enhanced the GSH levels in stress induced rats (Manikandan and Sheeladevi, 2005).

The results of the present study revealed that treatment with aqueous and alcoholic extracts of *Acorus calamus* normalized the activity of lipid peroxidation in liver tissue.

The present study revealed the antilipid peroxidation activity of *Acorus calamus* against paracetamol induced lipid peroxidation in rats. Hence, the *Acorus calamus* rhizomes can be used in treatment of liver disorders after detailed investigationof active compounds and the exact mechanism involved in the hepatoprotective activity. The usage of the herbal hepato-protectectives in the therapy reduces the cost of the treatment of the animal which will be economical to the farmer.

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Original Article

Detection and Diagnosis of Strain Variation in Canine Parvoviral Infections in Dogs

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Abstract

A total of 10 clinical samples and one known control sample in the form of rectal swabs werecollected from dogs showing signs of diarrhoea. The samples were clarified, processed and subjected to haemagglutination, rapid immunochromatography kit test and polymerase chain reaction assays. Of the 10 samples screened all (100%) were positive for CPV infections. Isolation of virus from the clarified faecal samples was done in both CRFK and MDCKcell lines. With one of the positive faecal sample SDS –Page was carried out. Strain variation was detected of which 10 samples belonged to CPV 2a and one sample belonged to CPV 2b by PCR assay with CPV-2ab primers and 2b primers. Partial sequencing based on VP2 gene was carried out with one of the CPV 2a isolate and phylogenetic tree was constructed to know the homology with other Indian isolates.

Keywords: CPV; HA; PCR Assay; Sequencing; Phylogenetic Analysis.

Introduction

Canine parvovirus disease is one of the most dreadful viral diseases of canines. The virus was first discovered in faeces of normal dogs in 1970 [4] and was called as Minute virus of canines (MVC) / CPV-1. This was the only canine parvovirus (CPV) until the report of a second CPV in 1978 [1] which was termed as CPV-2. CPV-1 was less pathogenic and not serologically related to CPV-2 [5]. Since its emergence in 1978, CPV-2 was well established as enteric pathogen in dogs and several wild carnivore species around the world causing high morbidity and mortality rates. The virus spread globally in a pandemic of disease during 1978,since then it remained as endemic disease in dogs throughout the world.

In India, CPV-2 is widely prevalent and is responsible for severe contagious gastroenteritis, dehydration and immune-suppression especially infecting young pups of two months age group. The virus infects intestinal epithelium leading to crypt necrosis, crypt dilatation and villous atrophy which are diagnostic of CPV infection. The monitoring and early diagnosis of CPV infection from field samples and molecular characterization has become fundamental tools to understand the virus evolution for developing effective preventive measures.

CPV-2 has mutated and spread throughout the world in dog populations and underwent genetic evolution giving rise consecutively to two antigenic variants, CPV-2a and CPV-2b that replaced progressively the original type CPV-2 [11, 17]. In 2000, a new antigenic variant, CPV-2c, was detected in Italy and rapidly spread to several countriesandthisnew variant was distinguishable from CPV 2a/2b by the substitution with Glu in position of Asn/Asp at 426 residues of the VP2 capsid protein and named as Glu mutant. [8, 18]. Additional amino acid difference was observed in both CPV-2a and CPV-2bin German CPV isolates in 1993 at position 297 (Ser to Ala) and was designated as New CPV 2a/2b [23]. The disease condition has been complicated further due to emergence ofnew of variants.

The present study was undertaken with the aim to characterize and compare the efficacy of tests for the effective diagnosis of Canine parvovirus. Preliminary screening of faecal samples infected with CPV was done by haemagglutination test with 0.8% Swine RBC followed by Polymerase chain reaction was employed for detecting the CPV from faecal samples. Molecular diagnostic techniques like PCR were the most reliable technique with high degree of sensitivity and specificity in detecting CPV from fecal samples [10, 13]. Characterization of VP2 gene of CPVfrom field cases will provide the necessary information of existence of new variants of CPV.

Materials and Methods

A total of tenfaecal samples were collected from dogs suffering from bloody diarrhea and vomitions from various veterinary hospitals located in Hyderabad, Andhra Pradesh and one known isolate as control was obtained from Indian Immunologicals Ltd. Hyderabad.

Methodology

The faecal samples collected in 0.2M Sorenson's PBS (pH 7.0) were clarified by centrifugation at 3000 rpm for 10 minutes at 4^0C and the supernatant was screenedfor CPV infection by haemagglutination (HA) test using 0.8% swine RBC. The Presence of CPV antigen in fecal sample was identified by Immuno-chromatography Kit (RapiGENCanine Parvotest kit) [9, 21]. The positive samples in HA with a titre of 1:32 and above were filtered by 0.22µm membrane filters and used for the isolation of CPV in CRFK and MDCK cells lines. The CRFK and MDCK cell lines were inoculated with 0.5ml of the processed fecal sample with 2% MEM (Gibco.) with FBS and passaged for ten times. At each passage, the presence of virus was confirmed by PCR with VP2 gene primers. In CRFK cell lines mild CPE with rounding and aggregation of cells and no significant CPE in MDCK cell lines were noticed. The CPV in CRFK cell lines was purified in10-40% sucrose in TE-EDTA buffer by density gradient centrifugation method at 207000g for 2h in swing out rotor [20]. The Purified virus was subjected to polypeptide analysis in 12%resolving gel by SDS-PAGE. The Polymerase Chain Reaction (PCR) was carried for partial sequencing of VP2 gene using two sets of primers 2ab and 2b [19].

Table 1:

Primer	5' to 3' direction
2ab-Forward	5'GAAGAGTGGTTGTAAATAATT3'
2ab-Reverse	5'CCTATATAACCAAAGTTAGTAC3'
2b-Forward	5'CTTTAACCTTCCTGTAACAG3'
2b-Reverse	5'CATAGTTAAATTGGTTATCTAC3'.

The PCR reaction mix was prepared with 5µl of 10x PCR buffer containing 5µl of $Mgcl_2$ (2.5mM), dNTPS (2.5mM),Taq polymerase (5units/1µl), forward and reverse primer 1µl each, 10 µl of DNA template and 27 µl of nuclease free water.Amplification was carried out with an initial denaturation of 95^0 C for 5 minutes, followed by 30 cycles of denaturation (94^0 C for 30 seconds), annealing (55^0 C for 2 minutes), extension (72^0C for 2minutes) and then final extension for 4 minutes at 72^0C. One selected VP2 gene PCR product was sequenced (MS MWG Biotechnologies Pvt. Ltd., Bangalore), analyzed and phylogenetic analysis was carried out using CLUSTAL W software.

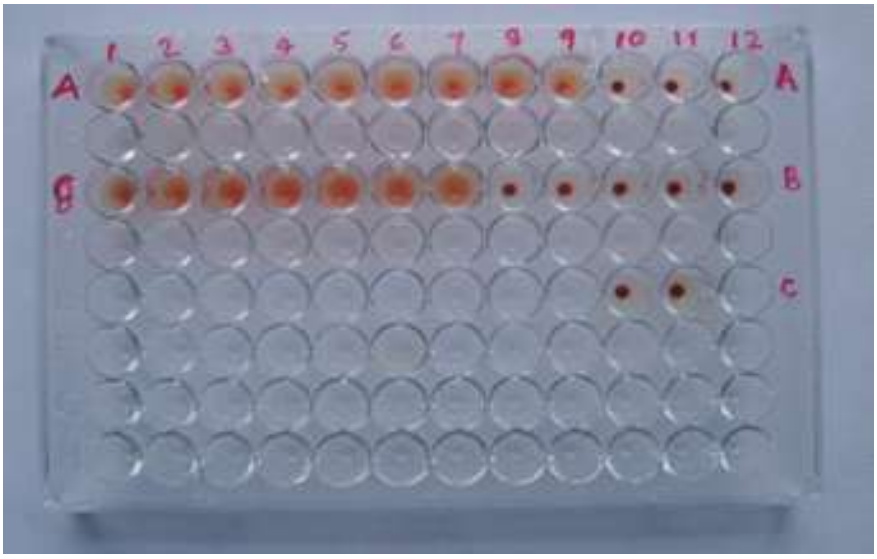
Table 2: List of CPV isolates employed for phylogenetic analysis based on VP2 gene sequences.

Identification code of the isolate	Country	Accession number
IIL 5	India	DQ182614
IIL9	India	DQ182615
IIL10	India	DQ182616
IIL11	India	DQ182617
IIL12	India	DQ182618
IIL14	India	DQ182619
IIL15	India	DQ182620
IIL17	India	DQ182621
IIL19	India	DQ182622
IIL20	India	DQ182623
IIL24	India	DQ182624
IIL25	India	DQ182625
IIL 27	India	DQ182626
IIL 28	India	DQ182627
GR 09/09	Greece	GQ8655519
140/05	Italy	FJ005265

Results and Discussion

The canine parvoviral infection studies revealed that infection may occur in both vaccinated and unvaccinated pups between age group of 2-6 months. Out of the total 10 affected dogs studied, 6 pups were not vaccinated shown relatively high severity of symptoms when compared with 4 vaccinated pups. The occurrence of parvoviral infection in vaccinated pups may be due to vaccination failure or any strain variation between the vaccine strain and the etiological virus strain. On preliminary screening of the 10 fecal samples by haemagglutination test with 0.8% swine R.B.C., all samples were shown a clear agglutination reaction with a HA titres ranging between 1:32 -1:1024 (Figure 1).The diagnosis of CPV by the rapid immune-chromatography test kit method revealed only four positive out of ten samples (Fig. 2). Here the samples which shown a high HA titre of 1:512 & above were only detected in rapid immune-chromatography method and the low HA titre samples were found to be negative in rapid immune-chromatography suggesting the haemagglutination test as a simple, reliable and least cost effective test for the preliminary screening of the parvoviral infection in canines [6,15]. The rapid immune-chromatography method lacks sensitivity in detection of low parvoviral load in the fecal sample [3]. The positive fecal samples in HA test were further confirmed by PCR primers for VP2 gene.

Fig. 1: Haemagglutination test



A. sample showing a titre of 512
B. sample showing a titre of 128
C. Control

Fig. 2: Rapid Immuno-chromatography Test

Above – Positive Below – Negative

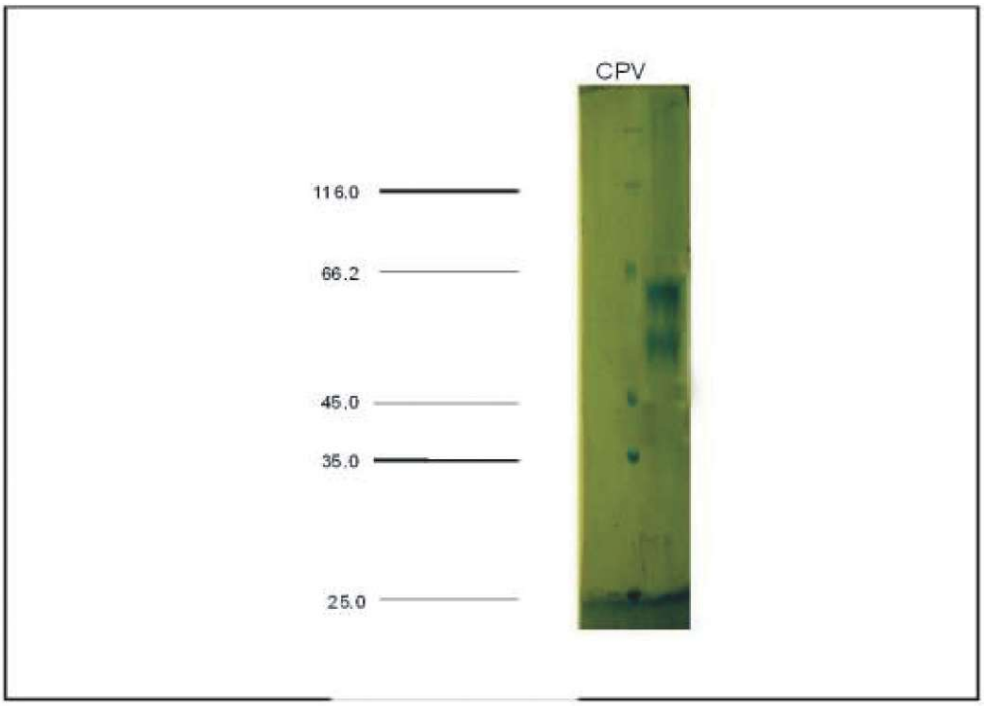
The positive facal samples were filtered through 0.22µm membrane filters and attempts were made to isolate the parvovirus from the ten fecal samples in CRFK and MDCK cell lines. The CRFK cell lines were best suited for the growth and isolation of the virus with the production of good minimal cytopathic effect [22]. The characteristic CPE was observed after 72h of post infection only after the 10th passage as focal rounding and clear aggregation.At each passage level the presence of virus was confirmed by PCR. The virus growth in MDCK cell lines was not significant with any detectable CPE. The CPV growth in MDCK cell lines may be varied depending on the strain of the virus [14]. Moreover the virus can be best studied in CRFK cell lines which are from felines than MDCK cell lines which are from canine origin [2].

The virus isolated from fecal samples in CRFK cell lines was grown in large quantities and concentrated by sucrose density gradient. The band formed at 20% sucrose level was subjected for polypeptide analysis by SDS-PAGE. The viral capsid contains three major proteins VP1 (82Kda), VP2 (65 KDa), VP3 (63 KDa) and VP2 is responsible for attachment, assembly of viral capsid and neutralization. The SDS-PAGE analysis revealed only 2 protein bands at 65 KDa and 62 KDa (Figure 3) The VP1 protein was not significantly observed, which might be due to the low concentration of the protein in the purified virus or the relative concentrations of the polypeptides may varied from batch to batch as reported by *Turiso* [24].

Table 3: Comparison of HA, PCR and Rapigen kit for Diagnosis

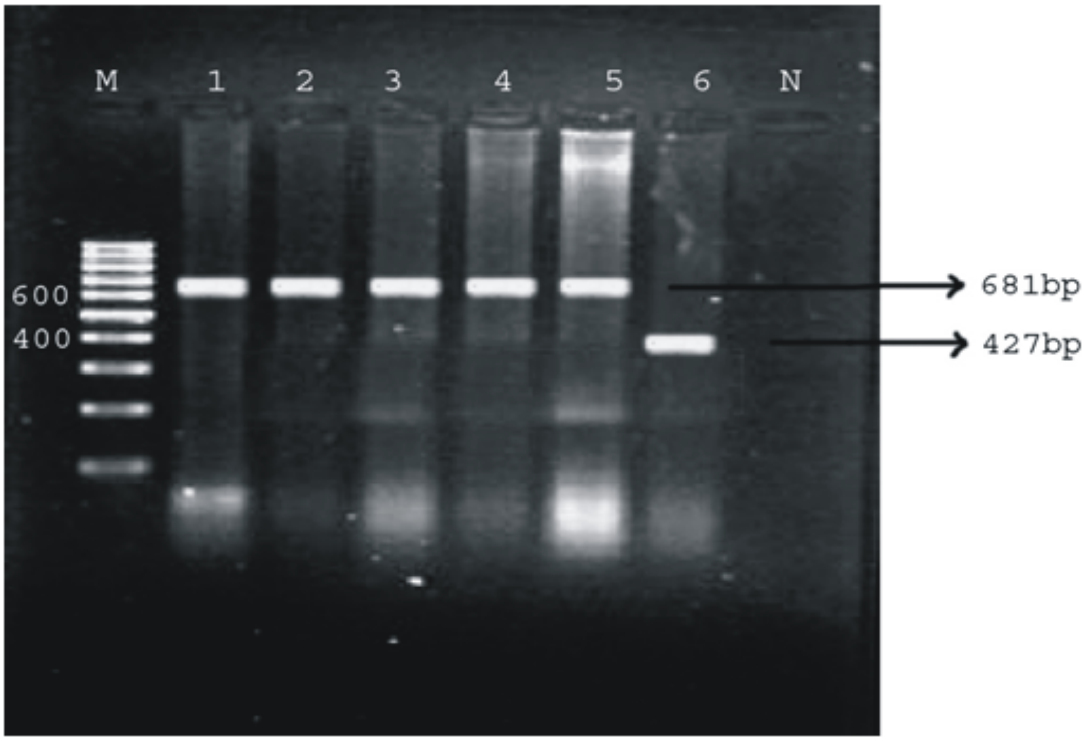
Sample No.	Results		
	Haemagglutination test	PCR assay	Rapigen Kit Test
1	32	+	-
2	32	+	-
3	512	+	+
4	64	+	-
5	1024	+	+
6	32	+	–
7	64	+	–
8	512	+	+
9	128	+	-
10	512	+	+

Fig. 3: Polypeptide profiles of CPV in SDS-PAGE gel
Two bands of CPV isolate visible with molecular weights 65KDa and 62 KDa



The CRFK infected cell culture fluid was directly used for amplification of Canine parvoviral DNA. The avoidance of DNA extraction step from the infected cell lines was more economical and time saving. Two sets of primers, one specific for VP2 gene of both CPV2 a and b strains (681bp product size) and another set for VP2 gene of CPV2b strain (427 bp product size) were used in PCRfor detection of the strain variation parvovirus [Panda].All the ten samples were amplified with CPV2ab primers with a VP2 gene product size of 681 bp. But out of ten samples, one sample was successfully amplified with the CPV 2b set of primers with a product size of 427bp. The control sample was amplified only with CPV 2ab set of primers with amplicon size of 681bp. The use of two different sets of primers for detection of strain variations in CPV infections was most succeeded in the present study. It detects the presence of CPV 2b strain in one sample out of the ten (figure 4).The past reviews emphasizing that the most prevalent strain of CPV in India was CPV2a. The incidence of high CPV2a strain infections in canines, out of ten, 9 samples were detected as CPV2a, strongly correlates with the previous reports. [7, 17].

Fig. 4: Polymerase Chain Reaction



M - Marker (100 bp)

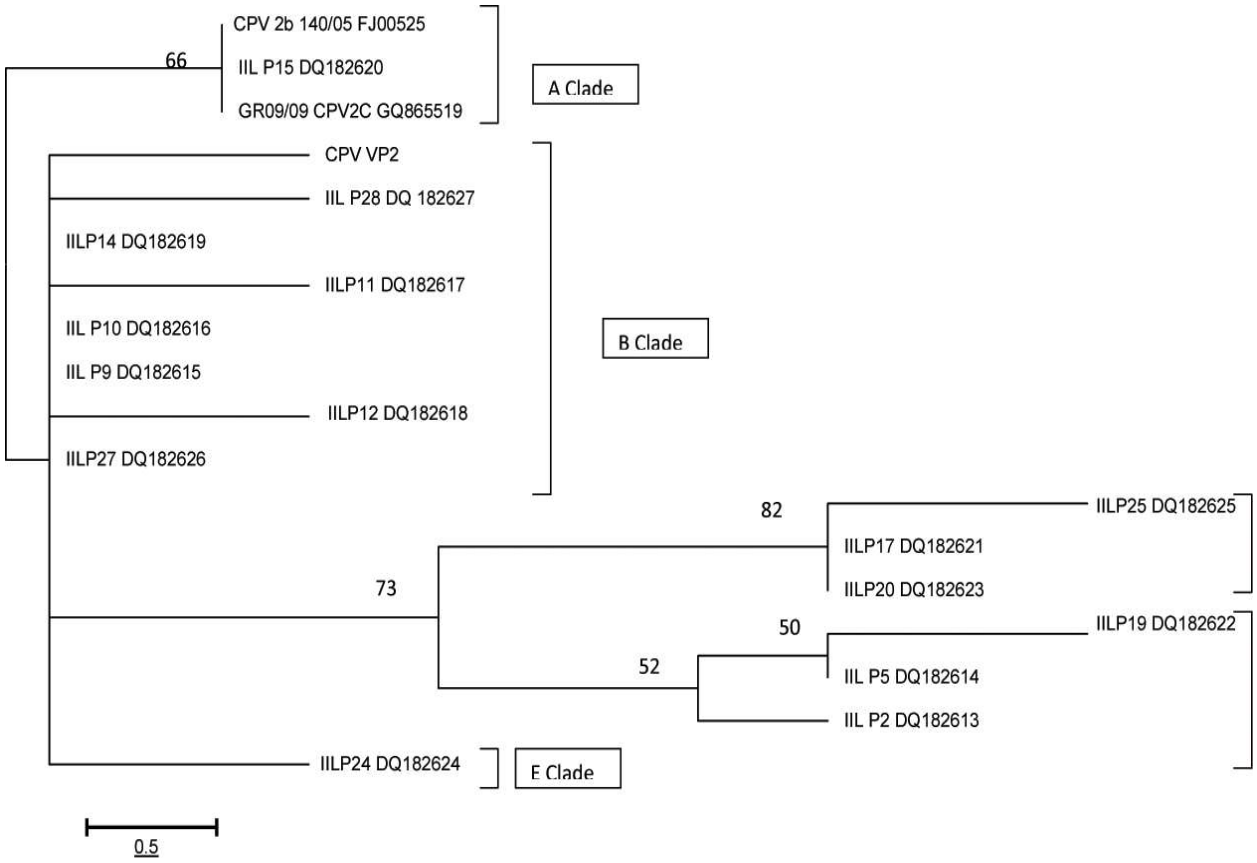
1 to 5- Samples positive for CPV 2a strain with CPV- 2ab primer (681bp)

6 - Sample positive for CPV 2b strain with CPV-2b primer (427bp)

N - Negative control

One of the isolated CPV2astrain's VP2 gene was partially amplified by specific primers with a PCR product size of 681 bp and was sequenced for further analysis.The Phylogenetic analysis was carried out and a phylogenetic tree was constructed using MEGA 4.0 software with the available CPV VP2 gene sequences of Indian isolates and two European isolates.A total of five different clades were formed (figure 5) and the tree emphasizing that the isolated CPV2a strain was fallen under clade B, along with other Indian isolates [7,12,16]. The European isolates were fall under a separate clade – A. However clade A contained both Indian and European isolates probably because phylogenetic analysis was based on partial VP2 sequence and not on complete sequence.

Fig. 5: The Partial nucleotide sequence of VP2 gene of CPV isolate



The Partial nucleotide sequence of VP2 gene of CPV isolate

5′ACAAATTGTAACACCTTGGTCATTGGTT GATGCAAATGCTTGGGGAGTTT GGTTTAATCCAGGAGATT GGCAACTAATTGTTAATACTAT GAGTGA GTTGCATTTAATTAGTTTTGAACAA GAAATTTTTAATGTTGTTTTAAAGAC TGTTTCAGAATCTGCTACTCAGCCA CCAACTAAAGTTTATAATAA TGATTTAACTGCATCATTGATGGTTGCATT AGATAGTAATAATACTATGCCATTTAC TCCAGCAGCTATGAGATCTGA GACATTGGGCTTTTATCCATGGAAACCAACCA TACCAACTCCATGGAGATATTATTTTCAATG GGATAGAACATTAATACCATCTCA TACTGGAACTAGTGGCAC ACCAACAAATATATACCA TGGTACAGATCCAGATGA TGTTCAATTTTATACTATTGA AAATTCTGTGCCAGT ACACTTACTAAGAAC AGGTGATGAATTTGC TACAGGAACATTTTTTTTT GATTGTAAAC CATGTAGACTAACACATA CATGGCAAACA AATAGAGCAT3′

Summary

The Clinical diagnosis of CPV infection in dogs was based on symptoms like fever, gastritis, haemorrhagic enteritis is quite suggestive to collect right samples for isolation or for molecular diagnosis. HA with swine RBC is an economical test for diagnosis of CPV infection and Rapigen kit test is less sensitive when compared to HA or PCR for the diagnosis of CPV infection. CPV can be isolated from fecal samples more preferentially in cells of feline origin than in cells of canine origin. By using two sets of primers the strain variation was diagnosed and CPV2a strain was detected as the most predominant strain in India. On phylogenetic analysis, it detected five distinct clades of which the isolated canine parvovirus was more genetically

related with that of the other seven CPV isolates of Indian origin.

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Original Article

Emerging Dairy Value Chain and Challenges in Global Economic Era

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Abstract

Policies in 1990s calls towards liberalisation and globalization make a dramatic shift towards structural transformation. Under such situation, how we can make strategy, preferring a short-term reactive approach over a more coherent long term sustainable approach towards inclusive growth which was emphasized during the existing Plan periods. Dairy sector has the capacity to reduce poverty and to reduce income inequality at the household level. Indian dairy sector has shown tremendous growth in terms of milk production, from 17 million tones (1950-51) to 132.4 million tones (2012-13). To enhance the dairy sector profitability, there is need to put more stress on value addition. To augment value addition in Indian dairy sector policy makers undertaken different policy changes in the post-liberalized era. But MMPO-1992 was introduced in post liberalised era to protect the interest of the cooperative as well as domestic small and medium size dairy plants. This amendment was one of the major policy changes to protect the interest of different stakeholders. Overall growth of dairy sector during the last two decades has been impressive. To restore the value addition in product and to harnessing the consumer market the involvement of organized sector is very much important. As per the finding of study value added products namely butter, cream, *ghee,* cheese and curd were found to dominate the value chain apart from the manufacture of pasteurized liquid milk in organised dairy sector. The mechanics of the organized sector penetration could be agency-specific as also area-specific. Need of the day is to provide quality input and output support services as provided by the co-operatives (Amul model at Gujarat, Nandani Milk Federation at Karnataka Model), private sector (Nestlé) and contract dairy farming. The scale up or success of each of these models depends upon the value added process which has the potential to satisfy dairy's inherent complementary nature of farm inputs, resources and institutional components.

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Reprint Request

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Introduction

Dairying is an important activity in Indian economy contributing about 27 per cent of the agricultural gross domestic product (GDP) and around 4.35 per cent of the national GDP (CSO, 2007-08). The total milk production has increased from 48.40 million tonnes in 1988-89 to 132.4 million tonnes in 2012-13 (DAHDF, 2013-14). This transition from deficiency to sufficiency has been achieved by a series of policy interventions by the government. It has been found that in the first phase of 'operation flood', growth rate of value-added products was 0.93 per cent per annum, but in the third phase, it became 9.10 per cent per annum (Singh & Datta, 2010). Milk processing in India is around 35 per cent, of which the organized dairy industry accounts for only 13 per cent of the milk produced, the remaining 22 per cent is processed in the unorganized sector. At production front around 70 per cent of dairy animals were reared by the smallholders and they owned about 52 per cent of landholdings (NSSO, 2003). To augment value addition in Indian dairy sector policy makers undertaken different policy changes in the post-liberalized era. Policy changes was due to the growing pressure of competition from global players

in the dairy sector, the tightening of the WTO Agreements as well as the anomalies in the license structure, the government made an amendment (in the year 1999) in the MMPO in 1992. The amendment allowed the dairy players to setup dairy processing units wherever and whenever they want to. MMPO-1992 was actually introduced in India to protect the interest of the cooperative as well as domestic small and medium size dairy plants. So, this amendment is one of the major policy amendments in the Indian dairy sector from government front in the post liberalized period. Overall growth of dairy sector during the last two decades has been impressive. A set of government policy which created suitable price environment for domestic milk production, is believed to be the key behind this impressive growth.

In this background this paper addresses the following issues: What are the opportunities and challenges for smallholder producers in dairy value chain? Whether organised supply chain and institutional arrangement play important role to shape the value chain system? What are the different alternative policy options to scale-up the sustainable supply chain system? What kind of policy and institutional changes are necessary, so that it may scale up the dairy value chain in FDI era?

Data and Methodology

The study is based on secondary data collected from different reports of National Sample Survey Organization (NSSO). Secondary data also collected from different dairy companies and Annual Survey of Industries (2010-11). To answer the different policy issues related to dairy supply chain primary data was collected from different parts of India. In this paper other studies (carried out at DESM Division of NDRI) also refer to look at the modern supply chains in dairy sector. Tabular and Gini coefficient analysis was used for data analysis.

Results and Discussion

This section examines a range of different successful value chain models that have emerged and developed in India. They include government, cooperative and private business initiatives with special focus on dairy value chain. Using the different primary and secondary data this section examines modern and traditional value chains with respect to the questions poised above.

Descriptive analysis of the dairy sector focuses on opportunities and challenges for the smallholder producers

Secondary data collected from Situation Assessment Survey of Farmers, NSSO 59th round, Ministry of Statistics and Programme Implementation, New Delhi, and NSSO 62nd round were assessed. It was found that marginal and small category of farmers in dairy farming formed 58% of all holdings, but accounted for as much as 71% of the in-milk bovine stock in 2002-03. The marginal category in the in-milk bovine population increased from 20% in 1971-72 to 31% in 1981-82, then to 44% in 1991-92, and finally to 52% in 2002-03 (Table-1). Changes in the stock of in-milk buffaloes per 100 households by category of

Table 1: Structural Changes in the operational holdings and *in-milk* bovine from 1971-72 to 2002-03 in India (No. in Millions)

Category	Distribution of in-milk bovine*				Distribution of operational holdings			
	1971-72	1981-82	1991-92	2002-03	1971-72	1981-82	1991-92	2002-03
Landless	2.49 (8.10)	1.27 (4.94)	1.22 (2.90)	0.32 (0.88)	15.59 (27.41)	18.11 (26.10)	20.35 (21.79)	32.46 (31.90)
Marginal	6.18 (20.08)	7.99 (31.15)	18.50 (43.91)	19.19 (52.03)	18.73 (32.93)	28.53 (41.11)	45.11 (48.30)	47.98 (47.15)
Small	5.99 (19.46)	4.83 (18.83)	9.15 (21.72)	7.21 (19.56)	9.36 (16.46)	10.06 (14.50)	13.26 (14.20)	11.45 (11.25)
Semi-medium	6.75 (21.94)	5.45 (21.24)	7.25 (17.21)	5.37 (14.55)	7.34 (12.90)	7.36 (10.61)	9.06 (9.70)	6.39 (6.28)
Medium	6.55 (21.27)	4.63 (18.06)	4.67 (11.09)	3.73 (10.11)	4.61 (8.10)	4.37 (6.30)	4.58 (4.90)	2.96 (2.91)
Large	2.81 (9.14)	1.48 (5.79)	1.34 (3.18)	1.06 (2.88)	1.25 (2.20)	0.97 (1.40)	1.03 (1.10)	0.51 (0.50)
All	30.78	25.65	42.12	36.89	56.88	69.4	93.39	101.75

Source: Singh & Datta (2013);
Note: Figures in Parenthesis is the percentage of all; *Bovine= Cattle and Buffalo

household operational holdings and the percentage of "in-milk" cattle and buffaloes to respective total stocks was studied from 1971 onwards and it was found that there has been an increase in the use of buffaloes in dairy farming (Singh & Datta, 2013). Distribution of land, dairy animals and farmers in different regions (northern, southern, eastern and western) of India was also studied and it was found that the eastern and northern regions together constitute over fifty percent of land, dairy animals, as well as farmers. The percentage distribution of land, dairy animals and farmers among different categories of farmers across different regions was also studied. The landless and marginal dairy farmers, constituting over seventy percent of all dairy farmers in the country, were found to own over sixty percent of all dairy animals (NSSO, 2003).

To study the production system and supply chain, *Haripal block* of *Hooghly district* of West Bengal was selected as it has the highest cross bred cattle density. Dairy farmers are generally keeping crossbred cattle and this area is producing significant amount of milk per day. They are selling the milk in different points (Table-2). Main proportion of milk is sold to *sweet making* shop on daily basis. In organised sector, milk collection centre of AMUL is one of milk marketing channel in the study area. *Sweet making* shops are giving money to the dairy farmers generally on weekly basis whether AMUL is paying cash on spot. Still they prefer *sweet making* shops for selling their milk for several reasons: on the occasions and festivals when demand of milk become higher, those shops are giving them more price; there is the myth working within them from their ancestors to sell the milk generally to households on the nearby towns or to sell them to sweet making shops; semiliterate dairy farmers are still not habituated with the system of *two axis pricing* of milk on the basis of *fat* and *SNF* percentage rather pricing system on the basis of quantity. Each dairy farmer is also keeping a certain portion buffalo within its herd. They are getting marginal higher price from AMUL by selling buffalo milk there. But there is the trend of keeping only *in-milk* buffalo as the maintenance cost of dry buffalo is quite higher as compared to cattle. When milking period of the buffaloes are over, those are sold to the agents on an average of Rs. 8000-10000 less than the price of buying.

To study the supply chain of respective state, data was collected from 24 Parganas District (North) of West Bengal, there are 4 main milk processing plants, namely *Metro Dairy*, Barasat (maximum capacity–5 lakhs litre/day); *Medow Food Product Pvt. Ltd*., Bamungachi, Barasat; *Ichhamati milk producers Union Ltd*., Berachapa, 24 PGS (N) (Maximum capacity 45000–50000 liters/day) and *Nest Dairy Farm*, Kathalberia, Barrackpore (maximum capacity 50000–60000 liters/day) in this district. There are also 3 major milk chilling plants which are: *Ichhamati*, *Red Cow* and *Amrit Fresh* in this district. Besides this, 50–60 *small chilling plants* are also located in this district. These major and minor chilling plants are always maintaining the balance sheet of demand-supply by charging different rates as per their controlling mechanism of milk producers and also dictating their terms and condition by diluting the cooperative norms. Within the cooperatives this direction was continuing as no professional players are involved to follow the cooperative norms.

Table 2: Milk Disposal Pattern in West Bengal (2013)

Type of Farmers	To whom the milk is sold (in Kg/day)			
	Sweet Making Shops	Middlemen	Agency (Amul/Mother Dairy)	Total
Large Farmers	626	213	65	899
	(71.51)	(22.14)	(6.34)	(100)
Medium Farmers	204	208	68	480
	(44.46)	(40.65)	(14.88)	(100)
Small Farmers	95	116	47	258
	(36.82)	(44.96)	(18.22)	(100)

Source: Socio- economic survey data (2013); Large- more than 20 milch animals, Medium- Up to 20 milch animals, Small- up to 10 milch animals;
Note: Figures in parentheses indicate percentage to total.

An overview of dominant dairy value chains and institutions in selected regions of India

Annual Survey of Industries (2010-11) data was used to identify the dominant supply chain in organised dairy industry. For this purpose all industrial units were classified in to the four parts i.e. public, private, cooperatives and other enterprises. As per the recent data (Table-3) it is clearly reflected that co-operative sector is one of the major supply chain (50.80 % GVA i.e., Gross Value Addition) in

terms of operational ownership. Whereas, second largest supply chain is private sector (21.01 % GVA). Third largest supply chain is under the public sector enterprises (19.37 % GVA). If we look at the dominance in terms of fixed asset (33.58 %) formation then also cooperative sector is one of the major supply chains. Similarly, public and private owned dairy organizations have 32.49 and 25.93 per cent fixed capital formation of organised dairy industry. So, fixed capital formation has been more or less same in these dairy organizations. If we look percentage share of each organization within the organised dairy industry then it shows that cooperative sector (53.04 %) is the major organization among all other organizations. Whereas, the finding of study private sector owned organizations are handling around 22.31% of milk used in organised sector. At the same time public sector organizations are dealing with 16.62% of milk. Moreover, cooperative organisations overall one of the major organization in terms of GVA, fixed capital formation and milk handling in organised supply chain. As these are the major determining factors for any supply chain management. So, dairy supply chain in organised sector is dominated by cooperative organizations. Gini coefficient of the milk used in the organised dairy industry shows that in cooperative organization there is more inequality (0.789) in comparison of private (0.763), public (0.709) and other (0.669) organizations. As within cooperative sector "AMUL" is one of major organization in Gujarat. In AMUL model famers are getting around 80% shares of consumer rupees. Similarly, in other state cooperative also famers are getting relatively higher share in consumer rupees. But, there penetration in northern and central part of India is not satisfactory. Therefore, it is provide a lot of scope for private and public sector. Therefore, in smallholder dairy farming system cooperative organization is one of the good propositions but where their penetration is not good especially in terms of milk collection from farmer's private and public sector organizations should take a lead. As in post-liberalised era private sector transform dairy processing sector by creating efficient supply chains management.

Table 3: Fixed Capital, Quantity of Milk used and Gross Value Addition (GVA) across the Organised Dairy Industry (2010-11)

Type of Organization	Fixed Capital (%)	Quantity of Milk used (%)	Gini Coefficient of quantity of milk used	GVA (%)	Fixed Capital (%)
Public Limited Company	25.93	16.62	0.709	19.37	25.93
Private Limited Company	32.49	22.31	0.763	21.01	32.49
Co-operative Society	33.58	53.04	0.789	50.80	33.58
Others	8.00	8.03	0.669	8.81	8.00

Source: Authors' estimates based on unit level data of ASI (2010-11).
Others: Individual Proprietorship, Joint family, Partnership, Govt. Departmental Enterprise, Public Corporation by Special act of Parliament/ legislator/PSU, Khadi & village industries commission, Handlooms and Others (incl Trusts, wakf board, etc).

To access the performance and challenges of different dairy supply chain under the ownership of cooperatives and private sector primary data and secondary was collected from Karnataka Milk Federation (KMF), GCMMF (AMUL), Nestle and Mother Dairy, New Delhi. Finding of study is helpful for us to know the management of supply chain in respective ownership.

The most important supply chain in Southern region was Karnataka Milk Federation (KMF). It has been supporting the livelihood of about 2.06 million milk producer members including 4.5 lakh women, covering 20,497 villages. About 11,836 Dairy cooperative Societies in the state promoting clean milk supply as "cows to consumer". Providing Rs. 2 per liter of milk procured by Dairy Cooperative Societies. Providing emergency veterinary services giving fillip to green fodder production and provide about 2.4 lakhs tons of cattle feed annually to support balance feed requirements. It's supplying the exotic Bull Semen for genetic improvement of milch cows. *Nandini Milk* in different varieties and Nandini milk products as a whole has caught the consumers test. About 96% of the DCSs are in profit as it is producer empowerment. Karnataka is one of the few states to have converted Dairying into an Industry.

The Mother Dairy model mainly guided on the principals on farmers depends substantially on the efficiency and the effectiveness of the co-operatives since it does not connect with the farmers directly. It

assists the farmer bodies to market the milk in the vast markets of the major urban areas–a capability many of them lack. Mother Dairy is facing competition from other organized retailers and maintaining quality is also a major challenge. It also undertakes the necessary investments for processing and distribution which is difficult for some of the farmer bodies to make.

Similarly, *Nestle* operates a network of 1,100 agents, who receive a 2.3 per cent commission on the value of the milk supplied to the dairy. The job of sourcing milk from farmers is done not by a co-operative society, but a private commission agent appointed by the company. Both the agent as well as the farmers is paid on a consolidated fortnightly basis, unlike the system of daily milk payments to farmers followed by *AMUL*. On an average, Nestle farmer pours about 7.25 kg of milk per day, whereas the corresponding figure for *AMUL* is around 2 kg per day, indicating that *AMUL* set up encompasses more number of small/ marginal farmers and landless farm laborers having only1–2 milch animals.

Conventional distribution channels consist of one or more independent channel members. But due to lack leadership and power, often result in poor performance which has been visualized from the case study of West Bengal. In contrast individualistic say or power makes isolation of milk producers from Northern India especially from Mother dairy milk Co operative which is dominated in the Northern part as well as in the eastern part significantly.

Whereas in the vertical Marketing Systems, it always consists of members acting as a unified system, use contracts, ownership or power or professionalism which is very much and to certain extent prevalent in the Southern and Western part of India.

The organised value chain and institutional arrangement to shape the modern and traditional value chain system

The milk market in India is fragmented, having both formal and informal segment, but the bulk of milk trade flows through informal supply chain. Recent study (V. Singh, 2011) from predetermined 100 farm households survey on 'Economic analysis of traditional milk marketing chain in Karnal district of Haryana' revealed that farm households had preference to informal sector to dispose off their milk. The disposal pattern of milk showed that about 92 per cent marketed surplus disposed off through traditional marketing chain consisting of milk vendors, creameries/private dairies and contractors, while only about 8 per cent by modern milk marketing chain comprising of milk cooperative societies.

Rising disposable incomes, changing dietary pattern, rapidly growing middle class and increasing awareness among Indian consumer has led to the diversification of the dairy category as consumers are looking beyond pouched milk and the occasional butter and cheese spreads. This gives rise to value addition in dairy products and developing of functional dairy industry in India. Indian functional dairy sector is dominated by pro-biotic foods. Indian pro-biotic market is valued at $2 million as per 2010 estimates and is poised to quadruple by 2015. At present, India contributes less than 1 per cent of global pro-biotic foods market. Amul is the leader in Indian pro-biotic market sharing 70 percent of market share.

Market survey research (Govindrao, H. P., 2013) from Maharashtra region shows that among all income groups, highest consumption expenditure was on pro-biotic drinks while lowest consumption expenditure on pro-biotic *lassi*. On average, each household consumes Yakult about 0.77 kg/month while fortified *dahi* was consumed about 0.36 kg/ month. Low fat dahi consumption in each household was found to be 0.32 kg/month. About 51 per cent of consumers would like to consume conventional dairy foods as daily basis while functional dairy foods were like to consume conventional dairy foods as daily basis while functional dairy foods were like to consume as monthly. Among the pro-biotic drinks Yakult was the most preferred brand while Mother Dairie's b-active pro-biotic *dahi* was most preferred among the pro-biotic *dahi*. Danone low fat *dahi* was the most preferred brand among the low fat *dahi* categories.

In order to identify alternative policy options, the status of production, consumption, prices, and farmers' income across different categories of dairy farmers in the selected zones was studied. Primary data was collected from 200 households in the 24 Parganas (N) district of West Bengal, 50 member dairy farmers of Kolar Milk Union, Mallur, Karnataka, and 100 households from the milk-shed area of Mother Dairy in Shamli district, Uttar Pradesh.

Eighty-six per cent of the total surveyed households in WB were found to be belonging to the small and marginal category of dairy farmers. The average milk production per household across all categories was about 7 percent and about 90 per cent constituted the marketed surplus. The surveyed households were found to be selling their milk (for Rs. 16 to Rs. 22 per litre) to any one of the four identified milk agencies in the region: the local

milkman or *Gwala/Dudhiya*, *Ichhamati* Milk Producers' Union Ltd., *Pipli* dairy, and Red Cow Dairy Pvt. Ltd. Of these, the backward linkage of *Pipli* was found to be the strongest.

The Kolar Milk Union, Mallur, Karnataka has 1600 DCS and they procure 7 lakh lts/day. The average number of dairy animals per household was found to be 2-3, and HF crossbred constituted 80 percent of the bovine population. The average price of milk was found to be Rs. 19.40 per litre. Its product mix included UHT milk, Toned milk, followed by curd, *peda* and *ghee*, among other products. Only 12 per cent of the total annual income of the marginal farmers was found to be coming from dairy, while dairy contributed 72 percent to the total annual income of the small category of dairy farmers in the region. All the surveyed farmers were provided with AI services by the Union, while 98 percent of the farmers said that they also received veterinary facilities, feed subsidy and mineral mixture by the Union, which shows a strong backward linkage.

From the 100 households surveyed in the Shamli district, data was collected on number of dairy animals, milk production, quantity of milk consumed and sold, and price of milk. 53 households belonged to the landless, marginal and small categories, with 2 to 3 animals per household. The average milk produced per household was found to be about 11 liters/day, while the average price/liter was found to be Rs. 26.95. The average marketed surplus across all categories of households was found to be 7.24 liters/day. The average number of milch animals was calculated to be 0.71, 1.14 and 1.43 for cross-bred, local cow and buffalo, respectively.

Based on the analyses of primary data collected from West Bengal, Karnataka, and UP, on various parameters, the identified alternative policy options to make small and marginal dairy farmers' dairy business more lucrative are: Value addition is a mechanism to accelerate the earning from milk by presenting innovative and desirable products which meet the customer demand and requirement. Milk is a basic raw material for all dairy products and earning per unit of milk is increased through value addition. This also helps to provide remunerative price to milk producers.

Ways and means to integrate the dairy supply chain in FDI era

After lot of discussions and protests, Government of India passed FDI bill in the parliament subject to state role is important one. With some conditionality's foreign firms can operate in Indian food and retail market. Some good feature incorporated in the revised FDI bill like 30 per cent local outsourcing from small and medium size industries, backward infrastructural investment to strengthen the supply chain and others obligations. These two obligations are very much important for dairy value chain. Indian dairy industry may observe three broad changes after FDI in multi-retail sector.

(i) The first important change that the multinational retailers are likely to introduce is state of the art storage technology that the multinational retailers possess and which is not known to big domestic retailers. This technology is expected to improve the supply chain and prevent wastage in a big way. Estimates of wastage of food grains, fruits and vegetables in the country vary between 20-40% of the total produce. It is argued that a significant part of this wastage would be avoided if foreign investors bring in state of the art technology. The primary case being made for FDI in retail is that it will increase efficiency. One source of this is improvements in the supply chain. In particular, this argument is applied to perishable agricultural produce. The claim is that increased investment will reduce wastage. Efficiency gains can potentially lead to gains for producers, intermediaries and consumers. Turning to the recent Indian experience, Walmart and other foreign firms have been involved in the wholesale trade for some years. For example, the Bharti Walmart joint venture works with over 6,000 small farmers across six states. Indian corporations have tried to create retail chains without foreign help. What do these experiences teach us about the potential for transformation? In neither case has there been a huge change in the supply chain. Logically, either FDI in wholesale or domestic retail chains could have made investments to improve the efficiency of the supply chain. There have been small improvements, but no great transformation.

(ii) The second big change that the multinational retailers are likely to bring about is more international trade. A little reflection will convince that the magnitude of international trade depends on the extent to which arbitrage possibilities across countries can be made use of. Making use of arbitrage possibilities, one can buy a commodity in a country where it is cheaper and sell it in another country where it is dear. A company job is to identify the international arbitrage possibilities and trade accordingly to make profits. It stands to reason that a giant multinational trader, with its more elaborate

procurement and distribution networks, will do the job more efficiently and extensively than a relatively small domestic retailer. But if that is so, entry of multinational retailers into the Indian market is likely to increase the volume of Indian international trade. In the recent year's different countries like Australia, New Zealand and EU interested to sign the Free Trade Agreement (FTA) with India and in near future India will do it because of international obligations. But this kind of trade arrangement will affect very much to the Indian dairy sector. As we know that New Zealand, Australia and EU countries producing milk in large quantity (with huge subsidies) that not demanded in the country. Therefore in the name of FTA these countries will dump their agriculture produce especially dairy product in Indian market. As Indian dairy industry is mainly dominated by the cooperative sector which connect million of resource poor farmers to the market and still this sector in nascent stage of development. It is important that government keep dairy sector away from FTA otherwise this kind of smart moves by the developed countries increases the arbitrage possible for dairy business for foreign big retailers. But as per FDI bill retailers would have to source 30% of their domestic sales from the domestic market. This would imply that they would have to market some Indian manufactures also, but the bulk of their sales should consist of foreign country primary agricultural goods or processed food products.

(iii) The third change refers to the scale of operation of big retail in India. The giant multinationals along with the domestic retailers with whom they are going to form joint ventures are going to have much greater financial power than the domestic big retailers alone. Therefore, in the new set-up, big organized retail is likely to cover a much larger portion of the market than before. There is concern in food and retail sector that some MNCs might use their monopsony power, their ability to access cheap products from domestic and foreign market, and use that monopsony power to give competition to domestic food companies. That's not a good basis for growth. It will definitely affect the domestic cooperative and private player of Indian dairy sector.

To protect the small and medium producers, processors as well as the consumers needs effective regulations. Effectiveness of regulations is must which is mainly depends not only upon the regulations themselves, but also on the regulator and the regulated and the environment in which they are implemented. Emergence of regulations can in turn be dependent upon these three. Will and wherewithal on part of the regulator on one hand and public pressure on the other are critical for successful implementation. Half-hearted negligent and poor implementation of regulations can benefit some at the cost of others who are less influential, less vocal or devoid of adequate resources. Equally importantly, if the regulator does not have the requisite information or is constrained by factors beyond his control, then again, the regulations may not achieve the desired objectives.

Conclusions

Operation Flood Program emphasis on developing smallholder-based dairy sector in the pre-liberalised era is justified on the ground that it realised the needs of the production base by the masses. Value addition in milk is unavoidable if one has to enhance sector profitability; the same does not seem feasible unless the organized sector improves its penetration. Because, it is the involvement of the organized sector that will drive the growth by resorting to value addition in basic product and harnessing the consumer market. The mechanics of the organized sector penetration could be agency-specific as also area-specific.

Cooperative sector is one of the major sectors in organised supply chain in Indian dairy sector. Gini coefficient of the milk used in the organised dairy industry provides the evidence that the in cooperative sector there is more inequality (0.789) in comparison of private (0.763), public (0.709) and other (0.669) organizations. Therefore, it is provide a lot of scope for private and public sector to increase its penetration where cooperative sector is not having good base. Need of the day is to provide quality of efficient input and output support services as provided by the co-operatives (Amul model at Gujarat, Nandani Milk Federation at Karnataka Model), private sector (Nestlé) and contract dairy farming. In the liberalised economy, the replication and scaling up of these models largely depends on the governance, institutional support and market forces.

The needs of the day is to invite private sector to build back-end infrastructure for collecting, processing and marketing of the milk and milk products which is augmenting from rural area to be procured directly from farmer-producer organisations. This will create millions of 'off-farm'

rural jobs, save on post-harvest losses, and create more efficient value chains giving a better deal to farmers and consumers alike, as also making our dairy globally competitive. This will immediately bring down food inflation of high value products. The government, therefore, should announce capital subsidy to the private sector for building such back-end infrastructure and also restrict the private players not to encroaches or concentrate in the location/ areas/ clusters where already cooperatives are working and protecting the interest of the farmers.

It essential to transform traditional supply chains from linear, sequential processes into adaptive supply chain networks in which communities of customer-centric, demand-driven, intelligently adapt to changing market conditions, and proactively respond to shorter, less-predictable life cycles. In the last 15 years, the share of milk producers has declined from 52% to 38% in USA and from 56% to 36% in UK. As compared to that, Indian milk producers get more than 70% on an average and the milk producers affiliated to co-operatives get more than 80% share of consumers' rupee. Key question is whether the organized retail trade would be able to operate at low margins as practiced by Amul and other co-operatives, failing which they would not be able to maintain the farmer's share in consumer price. Neither do our farmers receive fair price for their produce, nor do consumers benefit from low prices. The issue is not just about converting our farmers from price-takers to price-makers, but to balance the need of different interest groups by addressing the root causes of anti-competitive practices, which are rampant all over the country.

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Review Article

Different Ways of Financing Agriculture Extension

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Abstract

Recently a variety of ways to finance extension has emerged mainly as a result of the tendency to privatize government services and the increasing role, commercial companies play in agricultural research and extension. In many countries the extension service is either provided or funded by the Ministry of Agriculture. The government-funded extension is likely to focus its activities on public good activities which the market place is unlikely to provide. Decisions on the privatization of agricultural extension are often based on very limited knowledge about the consequences of such a change. There is more experience of privatization in industrial countries than in developing countries. But of course, Extension administrators may have to consider whether the recommendations of a consultant from an industrial country are really valid in their situation.

Introduction

In most countries agricultural extension has long been provided by a government service paid for by taxpayers. More recently a variety of ways to finance extension has emerged mainly as a result of the tendency to privatize government services and the increasing role commercial companies play in agricultural research and extension. This raises the question: What are the implications of the ways in which agricultural extension organizations are financed regarding the service that is provided to farmers? This paper addresses this question by focusing on the principles underlying decisions relating to optimal funding sources for extension. Since very little research has been carried out on this question and whatever little available has turned out to be scanty. This paper presents a conceptual framework that can be used in analyzing these implications and to show that decisions regarding how extension is financed have important implications for farmers and for the development of national agriculture.

Factors influenced by the ways in which an extension organization is financed

Box given below lists the major ways in which extension organizations can be financed. The mechanisms through which an extension organization is financed can affect the decisions

made by the extension organization relating to:

- Goals;
- Target groups;
- Extension methods used;
- Extension messages;
- Internal organization;
- Cooperation with other organizations promoting agricultural development.

Decisions that are made regarding these issues carry with them a number of implications for the ways in which extension supports farmers. Economists make a distinction between public and private goods. Everybody can benefit from the public goods, i.e. it is not exclusively or excludibly available to those who have paid for it and for public goods it is still possible for others to use the goods after it has been used by someone – this is usually the case with information. In contrast, only one person or organization benefits from a private good. Extension is usually somewhere in between a public and a private goods, but how close it is to either depends on the situation (Beynon et al., 1998).

Extension organizations can be financed by:

1. A government service paid by tax payers;
2. A government service paid by a levy on certain agricultural products;
3. A commercial company selling inputs to farmers and/or buying their products, which in relationship with its customers also uses extension;
4. A farmers' association which pays extension from its membership fees;
5. A farmers' association which is subsidized by the government;
6. A non-governmental organization (NGO) which is financed by donations from inside or outside the country and/or by commercial companies for public relations purposes;
7. An NGO which is financed by subsidies from or contracts with the government;
8. A consulting firm which charges a fee from the farmers, who are its customers;
9. A publishing firm which sells agricultural journals or other publications to farmers;
10. Different combinations of the above. For example, it is possible for a government to pay the salaries of extension agents, whilst most of the operational expenses are covered by a farmers' association, or for a commercially-oriented cooperative or input-supply company to send a farm journal to its members/customers.

What kind of farmer decision-making is the extension organization trying to influence? This might include:

- Adoption of technologies;
- Management of technologies;
- Optimal use of resources by a farmer;
- Change in farming systems;
- Changes in the supply of inputs/credit and the marketing of products;
- Transfer of the farm to the next generation;
- Changing from farming to another occupation;
- Collective decision-making on resource use and on the way farmers try to influence government policies (van den Ban, 1998).

In several developing countries, e.g. India, extension mainly places attention on the adoption of innovations, while in many former communist countries most attention is on investment and marketing decisions. Farmers all over the world may need support with the whole range of decisions. Is decision-making within the extension program centralized or decentralized? To whom are extension agents accountable? (Edwards and Hulme, 1996) These factors are inter-related; for instance information on a decision to adopt a technology is less excludable than information on the transfer of the farm to the next generation.

Why do different actors finance agricultural extension?

Actors who finance an agricultural extension

organization do so because they see it as a method to reach their own goals. Since the goals of different actors in an agricultural knowledge and information system (AKIS) are different, so are their reasons for investing in extension.

Government

The government will finance agricultural extension in the four cases and the same is mentioned below.

Situations in which a government should invest in agricultural extension:

i. When the general public benefits more from extension than the individual participants;
ii. For a type of extension which can be done better or cheaper by the government than by others;
iii. When government agricultural development programs can be made more effective if they are combined with extension;
iv. When necessary public benefits are not sufficiently provided by private enterprise.

Commercial companies

Commercial companies, including farmers' cooperatives, try to make a profit through trade. They will invest in extension only if they are convinced that this will promote their trade. It is usually in the interests of both the company and their customers that their products are used well. In the long term, a cooperative or commercial company will only make a profit if it is able to respond to the needs of the market. This may make it necessary to teach farmers how to produce the products for which there is a market demand. In order to be able to guarantee the quality of such produce, the marketing company aims to control the whole chain from the producer to consumer, because at each link in this chain something might happen which reduces the quality of the product.

In commercially-oriented agricultural production it is in the interests of both banks and some commercial companies that farmers are successful. The probability that a farmer is able to repay a loan from a bank depends on whether or not the loan has been invested for a good return without too much risk. It can also be in the interest of input supply companies for their customers to earn well.

Farmers' associations

Large and influential farmers' associations perform two main roles: (i) they try to influence collective decisions by the government and others in such a way that the interests of their members are taken into account; and (ii) they support their members in fields for which they have specialized knowledge.

Farmers' associations cannot only play a useful role by employing extension agents but also by putting pressure on research and extension organizations to work in a more demand-driven and client-oriented way (Collion and Rondot, 1998). However, one difficulty might be that the farmers representing the association are themselves relatively well educated and resource rich and may not fully understand the problems of resource-poor farmers with a low level of education.

Consultancy and accounting firms

Consultants who advise farmers for a fee have existed in many countries for a long time including India. They have been able to compete with the free advice given by government extension services because they visited their customers more frequently, providing services which an educational agency could not provide and they had more specialized knowledge of specific farming systems. This last point has become more important with the increasing specialization among farmers; to some extent private veterinarians have also been working in this way.

With the privatization of government extension organizations the market for consultancy services has increased rapidly. In several countries the government extension organization has been transformed into a commercial consultancy firm and the transformation required a change in attitudes of the staff members. Consultancy firms do business in the field of agriculture because they see a possibility to make a profit by advising farmers on particular issues. Farmers are most willing to pay for a tailor-made service, e.g. to help them to make decisions regarding investments and other issues for which they have limited experience. Large farmers are better able to pay the necessary consultancy fee than small farmers. Consultancy firms may also enter areas related to agriculture, particularly if they see possibilities.

Non-governmental organizations

It is difficult to generalize about NGOs because they display a wide range of variation in their aims and motivations.

- An NGO can be a religious related organization, which aims to improve the welfare of poor

people.

- An NGO can also be a group of entrepreneurs who earn their living by distributing grants from the government or from foreign donors to poor people.
- Another NGO might consist of a group of individuals who for political reasons want to increase the power of low status people.

There are many a reasons why extension services might be provided through NGOs and not through government, is to avoid working through an inefficient government bureaucracy. Compared to government extension agents, NGO staffs are also often better trained to support group formation among farmers. These groups can play an important role in agricultural development. On the other hand, staff members of several NGOs lack the technical competence needed to advise farmers on how they can increase their productivity. Thus, a collective effort will bring an overall development among the farmers.

Some implications of the way agricultural extension is financed

There has been little research into the implications of the way extension is financed for the way extension is given or for the way the extension organizations operate.

Flow of knowledge

The main feature of successful government agricultural extension organizations is the free flow of knowledge between researchers in different disciplines, extension agents and farmers. This made it possible to develop solutions for farmers' problems by integrating knowledge from different sources. Although the extension organization usually lacked the staff to contact more than half of the farmers on a regular basis, local opinion leaders were often able to influence other farmers by way of example and through discussions with colleagues. Farmers who have paid for information and advice are less inclined to share this knowledge freely with their colleagues. This 'commoditization' of knowledge may also reduce the consultants' access to farmers' experience and the freedom to use this information to help other farmers.

Knowledge management

The system of research-extension linkage is an important factor influencing the success of an extension organization. In several government extension organizations there is a well established system of subject-matter specialists who keep field workers informed about relevant new developments in research and inform researchers about the problems and experiences of farmers. It can be difficult to organize this linkage in a consulting firm. Competition may make it difficult to bring consultants from different firms together. An advantage of extension by commercial companies is that they are able to realize an integration of communication of new knowledge, input supply, marketing and credit supply.

Goals and accountability

The goals an extension organization tries to achieve are related to whom the staff of the organization feel accountable. In a government organization, the feel of accountability varies based on the rankings of the officials. Alternatively, an extension agent may feel accountable to their farmers since it is the farmers who influence their status in the community. In many developing countries extension staff tends not to feel accountable to farmers since farmers often have a low status in society. An important reason for governments to privatize their agricultural extension service has been that they have felt that they lack the budget to finance a large agricultural extension service. Therefore they have delegated this responsibility to organizations which raise their own budgets. Everyone occasionally makes mistakes, and the same is true of extension agents. If a farmer follows incorrect advice from an extension agent, he or she may lose a lot of money. Is the extension organization liable for these consequences or do the farmers have to pay for this loss?

Extension methods and approaches

Many extension scientists are now convinced that it is no longer desirable to use a transfer of technology approach in which the extension administrators decide on the targets to be realized by the field-level extension agents. A more participatory approach is instead preferred, in which farmers decide which changes are desirable and what kinds of support are needed from extension to realize these changes (Roling and de Jong, 1999; Haug, 1999). A participatory approach requires that the extension organization becomes a learning organization with the ability to discover which changes are desirable in each specific situation. It is easier to adopt a participatory approach or a farmer-led extension system within an NGO or a farmers' association than

in a government extension organization.

One problem with a participatory approach can be that some farmers expect their extension agent to provide services for them (i.e. how to solve a problem), whereas the extension agent sees himself as an adult educator, whose role is to encourage farmers to develop solutions for themselves. For a consultant who needs the fees from his customers to earn a living, it can be more difficult to realize this educational role than for a government extension officer, who will not be financially penalized if he refuses to perform a service role. A farmer can put pressure on the extension agent of a commercial company to provide free services by threatening not to buy the company's products any longer.

Target groups

Many of the poorest people in the world are small farmers with a low level of productivity. Although agricultural research and extension ought to be able to offer opportunities to increase their productivity and hence their income, these poor farmers do not constitute an attractive target group. The target group with which an extension organization works depends partly on decisions made by the organization but also on decisions made by farmers. It is evident that extension from a consultancy is mainly useful in helping a farmer to solve a specific problem rather than a problem which is faced by many farmers.

Management of the extension organization

In commercial companies and in consulting firms profit is an important criterion for management decisions. Staff members are not paid according to their age or level of education, as was often the case in government organizations, but according to the contribution they make to realize this profit. It has also been suggested that the cost of extension might be reduced by replacing personal contact between farmers and extension agents by mass media or by information and communication technology (van den Ban and Hawkins, 1996).

Conclusions

In many countries the extension service is either provided or funded by the Ministry of Agriculture. Other organizations such as commercial companies or NGOs may be involved both in providing and funding extension services and farmers themselves may also help to finance these services. Although it is hard to defend public funding of agricultural extension if the benefit is only for the farmers who use this service, there are many situations where the public at large also profits from the extension services, e.g. by lower prices for their food or a reduction in environmental problems brought about by a change in production.

The government-funded extension is likely to focus its activities on public good activities which the market place is unlikely to provide. Such activities include 'broad' rather than 'specific' technology transfer, dissemination of environmental and resource technology, and human resource development. Decisions on the privatization of agricultural extension are often based on very limited knowledge about the consequences of such a change. There is more experience of privatization in industrial countries than in developing countries. Extension administrators in developing countries should make use of this experience in their decisions. But of course, they may also have to consider whether the recommendations of a consultant from an industrial country are really valid in their situation.

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Review Article

An overview of Indian Meat Marketing: Challenges and Scope

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Abstract

Livestock sector is one of the most imperative components of agriculture in India. Despite the fact of large livestock population, the meat industry in India has not taken its due share. There are many reasons for the stagnant growth of the meat industry, including lack of implementation of scientific knowledge, inadequate attention of entrepreneurs, negative approach of public towards meat, socio-political considerations and improper retailing system. Most meats are sold in the domestic market without proper sanitary inspection and labelling. The situation is further associated by perseverance of domestic consumers to buy freshly cut meat from the wet market, rather than processed or frozen. In most of the domestic markets, the transaction takes place after examination of the animal by the byres through the broker or commission agent. Meat export market is substantiate and augmenting at acceptable pace by following sanitary and phytosanitary mandatory measures. Government of India has laid down standards for export market, which include standards for abattoir processing plant and various meat products. Though there are many promising outlook which support the potential for growth of meat industry at domestic market, there are still some moderation which if not treated sooner can faze the growth prospects of meat industry in India.

Keywords: Meat Industry; Export Market; Scenario; Prospect.

Introduction

Livestock sector, one of the most important components of agriculture in India, plays a critical role in the welfare of rural population. As per the Central Statistical Organization estimates the livestock sector contributes approximately 4.07% to Gross Domestic Product and employs 8% of the labor force. This sector is emerging as an important growth leverage of the Indian economy. As a component of agricultural sector, its share in gross domestic product has been rising gradually, while that of crop sector has been on the decline. In recent years, livestock output has grown at a rate of about 5 per cent a year, higher than the growth in agricultural sector. This enterprise provides a flow of' essential food products, draught power, manure, employment, income, and export earnings.

The contribution of livestock sector to the food basket in the form of milk, eggs and meat has been immense in fulfilling the animal protein requirement of ever-growing human population. India has a huge livestock population which includes 199.1 million cattle, 105.3 million buffalos, 71.5 million sheep, 140.5 million goats, 11.3 million pigs (DHAD, 2012) and efficient utilization of these resources including production and utilization of livestock products is important to earn increased returns and sustain livestock production activities. Meat is one of the most valuable and demanding food products harvested from livestock. Only 25g of meat can fulfill 45% of child's daily need for protein and half of vitamin B

(Isabelle Ortigues *et al.,* 2005). 100 g meat to the average diet will increase: protein 50%, iron 12%, niacin 40% and energy 25% (Eaton *et al.,* 1997). Meat consumption is growing throughout the globe and the variety of products available as convenience foods are on high demand. Meat processing in the East European countries, Asia and South America continues on an upward path. The continuously growing focus on automation along the entire meat processing chain is closely linked to the growing use of information technology. Hygiene and traceability are of crucial importance, requiring full monitoring of all processes along with the continuous documentation of origin and production data, in the interests of consumer protection.

Status of Indian Meat Industry

India is the richest country in terms of livestock resources and world's 5th largest producer of meat (MoFPI 2014). The present production of meat is 6.3 million tons (FAO outlook, 2014), which is 2.21% of the world's total meat production of 311.8 million tons. The export of meat in previous year was estimated at 1.365 million tons. The domestic per capita availability of meat is 5.5kg/head/year which is far below the recommendation of ICMR i.e. 10.95kg/head/year. The contribution of meat from buffalo is about 24.09%, while cattle contributes about 17.57%, sheep 4.68%, goat 9.48%, pig 5.39%, poultry 36.68% and other species 2.83% (FAO STAT, 2012). The compounded average growth rate during the last two decades works out to be 4.5%. It is noticed that about 7.3% cattle, 11.3% buffaloes, 33.7% sheep, 33.6% goats, 88.9% pigs and 57.6% chicken are slaughtered each year (S. K Ranjan, 2014).

India has 115 registered meat food processing industries, 279 licensed abattoir under A, B and C category of Meat Food Product Order and 40 approved Indian abattoir cum meat processing plants (APEDA 2014). Apart from these, the country also has 4700 registered slaughterhouses, most of which are in poor condition. A majority of these abattoirs are outdated (British time), inadequately equipped and unhygienic. Most of the meat for domestic consumption comes from poultry, sheep and goat that are slaughtered in unorganized/unregistered premises/meat shops. The produce of integrated modern abattoirs is primarily meant for exports and a negligible share is available for domestic market. The important importers of Indian meat include Maldives and Oman. The meat is being also exported to other countries such as Japan, Malaysia, Indonesia and Singapore. Only about 2-3% of the total meat is converted into value added products. The rest is purchased hot and consumed at home. Poultry processing is also at a nascent stage. India is emerging as the world's 2nd largest poultry market with an annual growth of more than 14%, producing 61 million tones or 3.6 percent of global egg production. The annual growth rate of egg production is 5-8%. Apart from this, India ranks 6th in broiler production (125 billion Rupees) with an annual output of 2.39 million tones of broiler meat, as per the estimates of the Ministry of Agriculture, Govt. of India.

The prime factors limiting processing include preference of consumer for fresh meat rather than frozen or processed, inadequate infrastructure and lack of human resource. However, with growing urbanization and increasing quality consciousness, the market for scientifically produced meat products is expected to grow rapidly. Demand for ready-to-eat and semi-processed meat products is also projected to elevate substantially because of changing life styles in modern era. Meat processing in India is an untapped industry having huge scope for investments. There is a large potential for setting up modern abattoirs and development of cold chains for the development of meat and poultry processing sector. Buffalo meat is surplus in the country with good export potential. Though the country is leading exporter of cara-beef in the world, but the figures are still insignificant considering the large population of buffaloes. Only 11% of the buffalo population is culled for meat Rigorous efforts are required to improve the condition of livestock by providing basic infrastructure and latest technology. The government has allowed 100 per cent FDI in the processing industry and has recently started the public-private partnership scheme for modernization of slaughter houses.

Constraints of Indian Meat Industry

Some major constraints for the meat industry are probably the lack of implementation of scientific knowledge for rearing the animal for meat purpose, improper nature of meat production strategies and marketing, socio-economic and political taboos associated with meat animal rearing and eating, inadequate infrastructure facilities and poor post-harvest management. Productivity of meat breeds has not tapped adequately. Livestock farmers are unaware of the potential of meat business. Livestock marketing is not well organized. There is no

integration of livestock farmers, meat producers, processors and marketing.

There has been hue and cry on health implications of meat especially for its high fat content leading to cardiovascular diseases. Society has also started to show concerns about ethical issues, such as animal welfare and the environmental costs of their consumption patterns, as meat production is very resource inefficient compared to other types of food production and places a burden on the ecosystem by using a great amount of water, land and energy. All of these factors have been influencing the consumer to give attention towards the development of modern vegetarianism. This may be viewed as a special case of cognitive dissonance in which a belief and a practice are in conûict, creating an unpleasant emotional state that people are motivated to resolve.

The structure of meat industry is highly unorganized and a substantial portion of meat production comes from clandestine slaughter. These practices often escaping mandatory ante-mortem and post-mortem inspection lead to production of poor quality meat apart from loosing economic revenues in terms of poor recovery of by-products. The environment pollution caused by such slaughter has also been a prime concern. Facilities for effluent treatment and waste disposal in these traditional slaughter houses are also far from satisfactory. The utilization of slaughter house byproducts such as skins, edible offal, blood and bristles is low and lacks the desired level of quality. There is lack of scientific implementation to effectively utilize dead animals and prevent environmental pollution through proper disposal of the animal waste materials in an appropriate manner, necessity for recovery of hide and skins. A critical assessment of the established centers is necessary to evaluate viability and continuation of the scheme. A concerted effort is required for popularizing appropriate disposal of dead animals including their burial in the event of unsound economics of modern rendering for prevention of environmental pollution and livestock disease control.

Marketing pattern of livestock products in domestic and international market

India has over 2000 markets where livestock are traded. Livestock markets are under the jurisdiction of the state governments although the direct operation and supervision would generally fall within the purview of the local bodies. State Acts regulate marketing of agricultural produce and the marketing committees are responsible for implementing and enforcing the provisions of the Act. The market for live animals in the country unfortunately has not developed on scientific lines. There are no separate markets for different species of animals. There are no separate enclosures for different species/animals. Brokers facilitate most of the trade. Vertical linkages between the processors/butchers and livestock producers are rare. Wholesale marketing margins amount to about 30% of the consumer price. Market facilities are generally inadequate and if available are poorly maintained. Weighbridges, ramp facilities for loading and unloading, feeding and watering and veterinary facilities are not available. Revenues generated under the act are supposed to be allocated to the markets for operations and improvement but not happening.

There is also Need to improve retail infrastructure and educate retailers about meat and meat products. Poor infrastructure and cold chain facility are the major stumbling blocks in the path of growth. There is large scope for meat processing in poultry as well as in red meat. The meat processing industry is still nascent. India exports both frozen and fresh chilled meat needs to be improve.

The value chain of meat production for the domestic market is very informal. Traders play a very active role in this value chain as intermediary aggregators as livestock owners have limited market access and are isolated from major consumers due to logistical and transport costs. Traders buy animals from various farmers and pool them for further marketing or haul purchased animals to municipal slaughterhouses. During transit of the animals from livestock markets to slaughterhouses health certificates from state veterinarians are also obtained. The animals are either sold to private abattoirs or slaughtered in the municipal slaughterhouse for a nominal fee and supplied to domestic market.

Strengths of Indian meat for export market

- Government of India has laid down standards for export of meat which includes standards for abattoirs, processing plants for various meat products. Registration of abattoirs and meat processing plants is done by the Agricultural and Processed Food Products Export Development Authority (APEDA).
- Government of India accords high priority to quality issues in meat for export. Therefore a stringent regulatory mechanism has been put in place by the Government in the form of

mandatory approvals of modern abattoirs for production of meat for export. APEDA is also enforcing HACCP and approves the plants with HACCP accreditation through an interdepartmental panel.

- Animal Health Certificate: According to the current Export and Import Policy of the Government of India, each export consignment is subject to compulsory microbiological and other tests and a comprehensive pre-shipment inspection certificate is issued by a Government laboratory. Each consignment is accompanied by this health certificate. The health certificate also confirms that the livestock have been subjected to ante-mortem inspection followed by post-mortem examination, and that the meat is fit for human consumption.
- India is a member country of the International Organization for Animal Health (OIE), and is mandated to report list "A" and list "B" animal diseases to the OIE at regular intervals
- The country being from diseases like BSE and Rinderpest has edge over several countries of the world.
- There is little practice of using hormones, antibiotics or any other chemicals to promote growth and fattening of livestock used for export purposes and the Indian meat is considered as nearly organic meat.
- Indian meat is also very competitive in international market and has created a special niche in most of the importing countries.

Conclusion

There is vast scope of Indian Meat Industry in both domestic and international market. Besides implementation of stringent sanitary and phyto-sanitary regulations, the strengthening of livestock and meat markets is essential to boost meat sector in the country. There is a dire need to create awareness among livestock farmers to rear their stock on scientific lines. Extension of proven research on meat animal production must be disseminated as a support to the poor entrepreneurs. The government interventions are also desired to provide platform for marketing of livestock and meat reducing the profit margins of traders so that the farmers get their substantial share. The guidelines for meat safety have been developed but their stringent implementation by Food Safety and Standard Authority of India (FSSAI) especially for domestic markets will win the confidence of consumer and certainly will help in boost the sector.

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Review Article

Scope, Prospects and Constraints of Freshwater Prawn (*Macrobrachiumrosenbergii*, De Man) Culture and Management Practices in Punjab (India)

Syed Shabih Hassan

Abstract

Variety of freshwater prawns (about 100 species) found all over the world of which 25 have inhabited the Indian waters. Among these, *Macrobrachium rosenbergii* (giant freshwater prawn is a crustacean species belonging to the family Palaemonidae) possessing high potential and great commercial importance in India and abroad. It is a hardy species by virtue of its ability to adapt to various types of fresh and brackish-water conditions. It is omnivorous, bottom dwelling animal, accepts pelleted feed and eat greedily. The giant freshwater prawn is suitable for cultivation in many natural freshwater bodies as well as low saline brackish water ecosystem in tropical and subtropical climates all over the world. Within recent years controlled hatching and grow out culture of marketable forms of this species have been tried in lentic water bodies in India and is still growing. Several culture management techniques have been adopted by various workers and found that the average production rate of freshwater prawn in India is 1-2 tonnes/ha/yr. Israel has reported 3,000 to 4,000 kg fish and 1,500-2,000 kg/ha prawns within a culture period of 7-8 months under polyculture operation. In India prawn culture with carps under polyculture practices has reported production levels of 600-1640 kg/ha/yr. However, prawns require optimum physico-chemical characteristics in water and rearing of prawn larva up to marketable size is a system specific. Presently, culture of *M. rosenbergii* is being done in most of the coastal states of the country. Inland states have also initiated prawn culture which may take time to standardize the production under different agro-climatic conditions. The assessment revealed that the growth and production of giant freshwater prawn is highly dependent on the suitable environmental conditions for commercial as well as greater management orientation. Therefore, the farming community and entrepreneurs must understand the scope, prospects, situation, features, impact and constraints of *Macrobrachium rosenbergii* culture, hatchery operation and its management practices on scientific basis.

Key words: Giant Freshwater prawn farming, scope, prospects, constraints, management practices

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Introduction

Aquaculture in India has a long history; there are references to fish culture in Kautilya's *Arthashastra* (321–300 B.C.) and King Someswara's *Manasoltara* (1127 A.D.). The traditional practice of fish culture in small ponds in eastern India is known to have existed for hundreds of years; significant advances were made in the state of West Bengal in the early nineteenth century with the controlled breeding of carp in *bundhs* (tanks or impoundments where river conditions are simulated). Fish culture received notable attention in Tamil Nadu as early as 1911, subsequently, states such as Bengal, Punjab, Uttar Pradesh, Baroda, Mysore and Hyderabad initiated fish culture through the establishment of Fisheries Departments. Indian aquaculture has been evolving from the level of subsistence activity to that of an industry. This transformation has been made

possible with the development and standardization of many new productions and associated techniques of input and output subsystems. The total inland fish production in the country registered growth from 1.2 tons in 1986 to 3.5 million tons in 2004-05, in which the contribution of freshwater aquaculture was way ahead of either brackish water aquaculture or capture fisheries sector on a constant basis. India is third largest producer of fish in the world with annual production of 6.4 million metric tons and second largest producer of inland fish, with annual growth rate of over 6%. The freshwater aquaculture at present accounts over 70% to total inland fish production. Carps, both Indian and exotic, contribute to over 90% of the total freshwater aquaculture production. This sector alone is contributing about one third of the total fish production in the country. The average production rate of freshwater prawn in India is 1-2 tons/ha/yr. Among the landlocked states, Punjab holds 5th position with highest fish productivity (6.09t/ha/yr) in the country, which is more than double the National average productivity (2.60t/ha/yr). In Punjab the area nearly about 9890 ha is under aquaculture. This state also has a vast network of water resources including 17,543 Km of rivers and canals, 5804 ha of reservoirs and wetlands and 8000 ha of village ponds, 1.65 lakh ha of barren/ waste land and 1.72 saline affected areas having immense potential for fishery development. Punjab produced 86000 tons of fish in 2005-2006 and >65 % production was contributed by the culture sector. Fish and prawn production can be enhanced through development of improved technology as well as suitable scientific management.

Prawn fishery of India with an annual catch of over 100,000 tons is second only to the United States and accounts for 18% of the world's production. Flourishing trade of exporting 'Prawn-pulp' to Burma and Malaya from earlier times and 'Frozen and canned' prawns to USA and Japan in recent years has made Indian Prawns a major foreign exchange earner. Export earnings from them have shown a steady increase in the last decade from Rs 115 million in 1961 to Rs 330 million in 1970. A part from being a delicacy, prawns is a rich source of proteins and vitamin A and D, most wanted to support the underfed human populations of the world. They contain considerable quantities of glycogen and free amino acids in their muscle which make their flesh so sweet and tasty. As they contain very little fat, they have become a favorite protein food for the weight conscious aristocracy.

In the tropical countries of Asia, the long legged giant prawn *(Macrobrachium rosenbergii)* has been known as food item for the people since long years ago. The prawn can attain big size which makes its capture wherever it occurs become an item for commercial venture. *Macrobrachium rosenbergii* is one of the freshwater species possessing high potential and good market demand. There are a number of species of freshwater prawns in India of which few are of commercial importance *(M. rosenbergii, M. malcolmsonii, M. villosimanus, M. birmanicum Choprai, M. mirabile, M. rude, M. idea, M. idella,* and *M. equidens)*the first two are larger in size and are more desired. Most of these prawns are crustaceans belonging to the family Palaemonidae. The now famous giant freshwater prawn, *Macrobrachium rosenbergii*, is a good example of this group. It composes an important fishery in many natural freshwater bodies in several tropical and sub-tropical countries all over the world. Within recent years controlled hatching and grow out culture of marketable forms of this species have rapidly expanded in many countries and is still growing. This species has a fine delicate flavour and commands good market price in local markets as well as in foreign trade in both developing and developed countries.

The average production rate of freshwater prawn in India is 1-2 tonnes/ha/yr. India accounts annual production (1979) amounted to about 350mt for *M. rosenbergii,* 4mt for *M. malcolmsonii*, 20 mt for *M. villosimanus;* and 125mt for *M. mirabile.* Although hatcheries and grow out culture are on trial, there is no information on production from this source. As per the available report, a maximum production of 4.2 tonnes/ha/yr has been achieved in Brazil, 2.5-3 tons/ha/yr in Taiwan and 280-4,000 kg/ha/yr in Veitnam, USA, Thailand, Porto Rico, France, Polynesia, Martinique, Dominican Republic and south African countries. Israel has reported 3,000 to 4,000 kg fish and 1,500-2,000 kg/ha prawns within a culture period of 7-8 months under poly-culture operation. In India prawn culture with carps under polyculture practices has reported production levels of 600-1640 kg/ha/yr. At present, culture of *M. rosenbergii* is being done in most of the coastal states of the country. Inland states Madhya Pradesh, Haryana, Punjab, Bihar, Tripura, Chhattisgarh etc. have also initiated prawn culture which may take time to standardize the production under different agroclimatic conditions.

Situation of prawn culture in Punjab and Haryana

Prawn farming was implemented in Haryana with an area of 70.06 hectares brought under fresh water

prawn farming. The state government has fixed a target of undertaking prawn farming in 100 hectares of fresh water area. At least, 119 farmers had been given subsidy and imparted technical know-how to take up prawn culture during the year 2004. The project of fresh water prawn farming was initiated in 12 districts–Yamunanagar, Karnal, Sonepat, Faridabad, Gurgaon, Jhajjar, Rohtak, Bhiwani, Fatehabad, Sirsa, Hisar and Jind. The department not only provided technical know-how to the fish farmers for undertaking prawn farming in fresh water but also took them to a study tour to Andhra Pradesh so as to acquaint them with the latest practices being adopted there.

Two other projects to develop water-logged areas into aquaculture estates and utilization of saline water for fish and prawn culture were also being implemented with 100 per cent assistance from the Union Ministry of Agriculture. Under the project, 18.7 hectares of area was brought under fresh water prawn culture by imparting training and technical know-how to the farmers in the districts of Gurgaon, Rohtak, Jhajjar and Sirsa. Under the project for utilization of saline water, 23.2 hectares of water area was brought under fish or prawn culture by providing benefit to the farmers in the districts of Gurgaon, Jhajjar, Rohtak and Sirsa. Under both these projects, 100 per cent assistance was provided to the farmers at a rate of Rs 2.30 lakh per hectare, which included Rs 2 lakh for development of area and Rs 30,000 for inputs.

As it was a new technology, the scientists identified the sites and the experts analyzed soil and water before using them for prawn culture. The seeds of prawn were procured from Andhra Pradesh and Tamil Nadu. Both these projects were being implemented since 2002-03. As per the figures of the Fisheries Department, a total area of 8,760 hectares was under fish culture as on March 2004. At least, 39,133 tons of fish was produced in the state during that period. As many as 8,120 fish farmers were benefited by the training and incentives providing by the department. At least, 17,660 farmers in the state were presently engaged in fish farming. An additional area of 663.25 hectares was brought under fish culture during the last financial year.

Seven villages in Punjab took up prawn farming in the year 2003 alone. These are Badshapur, Kapurpind, Kah Kalan and Barra Pind in Jalandhar district, Dogawalli village in Kapurthala district, Punnia village in Sangrur district and Kishanpur in Ropar district. Mr Nirmal Singh was also adopted prawn culture in Jalandhar but could not continue. The trial on prawn farming was also conducted by CIFA scientist at Ludhiana without any success story. Mr. Rajwinder Singh is also importing prawn from other state for the local consumer in Ludhiana. Recently, a farmer Mr Ajitender Pal Singh Cheema has commercialized prawn farming after stocking 14000 seeds in 0.28 ha area by using Godrej Agrovet Scampi feed and blower/ aerator at Rasulpur village Distt-Barnala and earned Rs 57,000/- per crop in 7 months (April to October). Mr Cheema is doing freshwater prawn farming in a very amicable and eco-friendly way. At present, Mr Cheema is the only farmer in Punjab who is involved in prawn farming. He is now planning to increase prawn culture area for *Macrobrachium rosenbergii* to fulfill the need of the consumer as well as to gain maximum output.

Special Features of Freshwater Prawn Species in Aquaculture

Freshwater prawn culture has now a day gained much commercial importance for its rising internal market demand and export potentialities. More than forty species of *Macrobrachium* commonly occur in Indian waters, but only a few like, *M. rosenbergii, M. malcolmsonii, M. birmanicum Choprai, M. villosimanus, M. rudae, M. idea, M. idella,* and *M. equidens.* Among these *M. rosenbergii* are most suitable and potential species for freshwater prawn farming in the state of Punjab because it grow fast and large size compare to other species. The other two species, *M. malcolmsonii* and *M. birmanicum choprai* is also in order of merit for culture in our freshwater. It can be a good diversification option for agriculture farmers besides generating employment and providing nutritious food to the consumers.

The natural distribution of these species as original habitat in river has immensely accepted for their culture by fisher folk in different parts of our country. Availability of *M. rosenbergii* in the river systems is limited to estuarine zone with a maximum of about 100 kms from the sea shore while *M. malcolmsonii* is available throughout the length of river system starting from its point of origin to the point of joining the sea making it easy for culture throughout the country. On the contrary, *M. birmanicum choprai* is found to be available in the middle stretch of Gangetic system only, limiting its culture area accordingly in North India. The other common medium and small sized *Macrobrachium* sp. *M. lamarrei* and *M. idea* are available throughout the river stretch and connected lakes and canals where as *M. scabriculum, M. equidens, M. idella, M. villosimanus,and M. rudae*are limited to coastal areas and deltaic regions.

1. *Macrobrachium rosenbergii De Man,* (Giant River Prawn) is the largest freshwater prawn in the world. It is mostly distributed in the estuarine and freshwater zones of river mouth and backwaters (salinity range 0–20 ppt) in the tropical and sub-tropical areas of Indo-Pacific region. Recent developments in hatchery seeds production techniques, have transformed *Macrobrachium rosenbergii* farming as a major profitable aquaculture activity in countries like Thailand, Taiwan, Hawaii and Mexico. It is introduced into several countries in Africa, Europe, America, Asia and in New Zealand where suitable temperatures (14–34 ^{o}C) for its culture and obtainable naturally or optimum water conditions 25–30 ^{o}C are created. Male attains length 34 cm where as female 26 cm.

   M. rosenbergii is elongated sharply upturned rostrum with an elevated crest reaching beyond antennular peduncle having rostral formula 13-14/11-13. Rostrum is as long as or longer than carapace. Horizontal black or brown dotted lines are on the carapace ranging from one in number in the smallest to eight on the bigger specimen which disappear in bigger specimen. Tip of the rostrum red; black or yellow dots on each abdominal segment on each abdominal segment on both sides. Having longer and slender body juvenile moves faster than other species who have more bulky and broader body shape; second cheliped is much longer than the total body length more so in male which is stouter.

2. *Macrobrachium malcolmsonii* (Monsoon River Prawn or Indian River Prawn) is available in the rivers of Indian sub-continent. In India it is very common in peninsular rivers that drain into Bay of Bengal. This species is in the habit of crawling out of ponds in the grassy bunds during drizzling heights and hence protective devices to prevent their escape are to be installed. Maleattains length 23 cm where as female 20 cm. The hatchery technology of this species has been achieved in 1991.

   Rostrum of *M. malcolmsonii* is shorter than carapace having conspicuous convex proximal upper margin. Dorsal teeth unevenly spaced with noticeable irregularity in serration in the distal half which is without teeth. It has more than 9 dorsal teeth on the rostrum. Rostral formula 12-13/4-7. Tip of the rostrum red. Horizontal black or brown dotted or discontinuous lines on the carapace may be one to four in numbers. Which disappear in bigger specimen; black or golden yellow dots on each abdominal segment on either side. Having longer and slender body juveniles move faster than other species who have more bulky and broader body shape; Second cheliped is much longer than the total body length more so in male which s stouter.

3. *Macrobrachium birmanicum Chopra*i or *M. Gangeticum* (Ganges River Prawn) looks similar in appearance and size as *Macrobrachium malcolmsonii* and often confused for the others. Available in Ganga river system and suitable for culture in Gangetic plains. It attains length 190 mm. The hatchery technology of this species has been achieved recently in the year 2000. Rostrum short with conspicuous elongated proximal crest with 9 to 10 teeth and distal end with only 1 to 2; ventral teeth 3 to 4 rarely 5 to 6.

4. *Macrobrachium villosimanus* is available in the Hooghly River system. It attains length 14 cm. Rostrum more strongly upturned distally with less elevated crest. Rostral formula 12-14, 7-10. Dorsal teeth larger and uniformly arranged, longitudinal dotted lines on carapace.

5. *Macrobrachium rudae* is distributed from South African continent to Burma. In India form good fishery in rivers of the east coast (Bengal, Orissa, Andhra Pradesh in particular). It attains length 13 cm. Rostrum more blunt and shorter. Its dorsal margin slightly convex with 12 or more teeth continuously arranged. Presence of 3 or 4 characteristics transverse lines or dark bands on carapace.

6. *Macrobrachium idea* is distributed from East African coast to Phillipines in rivers and estuaries, seems a rare species in Kerala.Male attains length 11 cm where asfemale 9 cm.

   Rostrum without an elevated rostral crest and not reaching beyond tip of antennular peduncle. Dorsal margin of rostrum straight with less than 12 teeth.

7. *Macrobrachium idella* found in the Rivers and estuaries of south west coast of India.It attains length14 cm.

8. *Macrobrachium equidens* found in East and West coast in fresh and brackish waters but small numbers. It attains length 10 cm.

9. *Macrobrachium josephi* is another Indian freshwater prawn species which is larger in size and recorded maximum about 185 mm total length from VeliLake and Kulathoor Rivulet in Trivandrum.

10. *M. scabriculum* attains average length about 6 cm and found in West Bengal, Orissa, tamil Nadu, Andhra Pradesh and Kerala.

11. *M. lamarrei lamarei* attains average length about 6 cm and found in all states.

Prospect of Freshwater Prawn Farming (*Macrobrachium rosenbergii* De Man)

Although India has vast freshwater resources they are not fully exploited except for carp culture in limited scale. Fresh water fish culture employing composite fish culture technology has become popular for use in large number of tanks and ponds in the country. To meet the raw material required by the processing units for export demand there is urgent need to expand our production base. In addition it is always stressed that there is a need to utilize our natural resources productively to ensure required food security.

The freshwater giant prawn has been known as quick growing and is a superior animal for culture. Experimentations to grow *Macrobrachium rosenbergii* have been tried by several workers since before 1960. Workers in Thailand started growing prawn in earthen ponds in 1956 with juveniles collected from the open waters. From the experiments, it shows that *Macrobrachium* could well be used for pond culture. Young prawns are able to survive well in varied types of freshwater, provided that the water contains enough amount of dissolved oxygen. The rearing of larvae to juveniles and from juveniles to grown adults of marketable size, growing prawn in ponds has evolved. The giant freshwater prawn can even be cultivated in irrigated paddy-fields that are able to retain water depth not less than 15 cm. At present, information available does not identify any other species with greater potential than *Macrobrachium rosenbergii*. The technological development of *Macrobrachium rosenbergii* in the form of captive breeding and post larval production, the species is recognized as one of the major commercial aquacrop species in countries like Malaysia, China, Vietnam, Thailand, India, Bangladesh, Pakistan, Korea, Japan etc. Freshwater prawn has become suitable commercial species to be cultured along with other species in different culture practices (Kurup *et al*., 2002; Kutty 2005, Kunda *et al.,* 2008; Asaduzzaman *et al*., 2009). The culture technique of growing prawn is relatively simple due to the resistance of the animal to changes of environmental conditions such as temperature and salinity and it is omnivorous in nature. Production cost is low and the product is highly valued in the market. The demand of prawn is getting progressively greater; hence efforts for increased production are necessary. The freshwater giant prawn has now become a subject of efforts to cultivation.

Scope

Considering the high export potential, the giant fresh water prawn, *Macrobrachium rosenbergii,* the scampi, enjoys immense potential for culture in India. About 4 million ha of impounded freshwater bodies in the various states of India, offer great potential for fresh water prawn culture. Scampi can be cultivated for export through monoculture in existing as well as new ponds or with compatible freshwater fishes in existing ponds. It is exported to Europe and USA. Since the world market for scampi is expanding with attractive prices, there is great scope for scampi production and export.

Prawn farming *(Macrobrachium* sp.) picks up in the states of Punjab and Haryana. Farmers in Punjab produce 5.4 tons per hectare, those in Haryana 4.5 tons per hectare. In Haryana, 40,000 families depend on prawn farming for their livelihoods, and 10,000 ponds have been constructed, 80 percent of them operational. About 700 hectares of prawn farms exist in Punjab. Haryana and Punjab has a marketing advantage due to close to Delhi, where it sells 90% of its production. Farmers in the two states are also doing polyculture fish in their prawn ponds and to follow the April to October prawn season with a crop of fish. As per the state Govt. record, "The state had 5,726 units at present covering a total area of 7,327 hectare under fish culture. Out of this 2,686 units had been set up by farmers on their own land covering an area of 3,084 hectare. The remaining 3,037 are panchayat village ponds covering 4,243 hectare. The total fish production in the state from all sources has touched 6,580 metric tons." It is thought that as many as 2,113 people received training in aquaculture in 2002-03. A farmer could earn about Rs 60,000/- per hectare per year from prawn farming, compared to Rs 20,000/- per hectare from wheat or rice. The quality seeds of prawn for stocking of pond can be procured from Andhra Pradesh, Tamil Nadu, Bhubaneshwar (Orissa), Kolkata (West Bengal) and Raipur (Chhattisgarh).

Impact

In general at present, there is significant decline of catch from natural stocks almost everywhere in countries in the region. Harvest has diminished

owing to indiscriminate fishing which causes the stock decrease soon. The reduction of stock is also due to the destruction of habitat by human being. Construction of dams, roads and factories in the lower reaches of the river systems leads to the reduction of the dispersal area of the prawns including the spawning and feeding grounds. Water pollution is another factor which is positively deplete on the growth and abundance of the stocks. The development of the technique to hatch *Macrobrachium rosenbergii* under controlled conditions as well as the nursery rearing of the larvae and post-larval stages of this species has greatly stimulated the expansion of the culture of this species of prawns. However, recent introduction of *Macrobrachium rosenbergii* in India has lead to the development of giant prawn culture of commercial scale. Prawn and fish farming can be expanded in Punjab because it is less risk and ease of marketing over traditional agriculture activities and, of course, greater returns. The farmers can turn from paddy-wheat rotation towards alternative agricultural production i.e. fish and prawn farming in the state of Punjab. It will usher in the utilization of water resources and side by side economic development of the Punjab farmers.

Possibility

Prawn production requires careful management and is hindered by a general lack of technical information, particularly the proper use of chemicals for water quality control and weed control. The evaluation of prawn production in Punjab should be expanded in saline water zone. Variable juvenile

Initial Requirement for the Culture of *Macrobrachium rosenbergii* (Capital Cost)

1.	Location of pond	:	Good location, available electricity, water and transport facility
2.	Farm Size (Area of Pond) (Construction of pond including digging, bundh Rs 50,000/- construction and compaction and consolidation)	:	(0.5 ha)
3.	Pond Depth	:	5 to 6 feet
4.	Culture Period	:	6-8 months (April to November) Only one crop of 6-8 months culture period will be considered.
5.	Mustard Oil Cake	:	Rs 1700/- (cost for 200 kg)
6.	Lime	:	Rs 1500/- (cost for 500 kg)
7.	Air Blower/Aerator	:	Rs 30,000/-
8.	Generator	:	Rs 1,00,000/-
9.	Refrigerator	:	Rs 15,000/-
10.	Shallow tubewell and water pumpset 5 HP	:	Rs 50,000/-
11.	Inlet/Outlet Sluices	:	Rs 10,000/-
12.	Pump house cum store room-AC roof	:	Rs 20,000/-
13.	Cost of Prawn seed	:	Rs 15,000/- (@ Rs 1 per pc)
14.	No. of Seed to be Stocked	:	15,000 nos. (stocking density@30000 per ha expected Survival rate 60 to 70% of stocking
15.	Godrej Agrovet Feed (Scampi feed/ Pelleted feed)	:	Rs 28,000/- (1000 kg @ Rs 28 per kg)
16.	Nets and other implements(Cast/Seine net)	:	Rs 10,000/-
17.	Labor for crop harvesting	:	Rs 2,500/-
18.	Ice for crop transportation	:	Rs 500/-
19.	Diesel to pump out water	:	Rs 1500/-
20.	Pumping and Aeration charges	:	Rs 5000/-
21.	Transportation of seed from Delhi (Bhuwaneshwar/Raipur/Andhra) to Ludhiana	:	Rs 1500/-
22.	Vehicle charges for prawn sale	:	Rs 4000/-
23.	Watchman-cum-Labor charges	:	Rs 12,000/-
24.	Ice box	:	Rs 2000/-

size and quality, variable food supply, and pH control may be most important in determining prawn yields. The state of Punjab has vast freshwater resources and optimum weather condition, the state has a great potential for prawn culture with a little bit of support from the government like timely availability of seeds through establishment of prawn hatchery, feed and marketing of the produce. There is a lot of possibility to bring wasteland, waterlogged area and area with saline culture under prawn farming with concept of sequential culture, i.e. prawn during summers and fish during winters for gaining maximum output. The proper utilization of available non-productive resources (viz., 1.65 lakh ha of barren/waste land and 1.72 lakh ha saline affected areas) for aquaculture will immensely enhance the rate of fish as well as prawn production in the state.

Technical Parameters for the culture of freshwater prawn

The giant freshwater prawn is suitable for cultivation in tropical and subtropical climates. It is a hardy species by virtue of its ability to adapt to various types of fresh and brackish-water conditions. It accepts pelleted feed and has omnivorous feeding habit. In the natural environment, lower reaches of rivers, tidal inlets, where water is directly or indirectly connected with sea are their preferred habitat specially during spawning. The breeding takes place in low saline waters which is also needed for larval and post larval development after incubation. Breeding of *M. rosenbergii* takes place in estuaries. Though seed may be available in natural sources to a limited extent, for large scale culture there is a need to ensure regular supply of seed. For ensuring availability of quality seed in predictable quantity freshwater prawn hatcheries should be encouraged, technology for which is already developed. Freshwater prawn hatcheries are coming up in many states.

Pond Construction and Water Supply

The site selection plays an important role as the entire management aspect of the farm ultimately depends on specific conditions of the site. The aspects to be considered are topography of the area, soil type, availability of quality water etc. The area should be free from pollution and flooding. Other considerations like approach roads etc. have also to be taken into account. Rectangular ponds are suitable mainly from the harvesting point of view. A convenient width is 30-50 m, whereas length of the pond depends on site, topography and farm layout. Normally a size of 0.5 to 1.5 ha is found suitable. The average depth of the ponds should be 0.9m with a minimum of 0.75m and a maximum of 1.2m deep clear water with sandy-loam soil bottom for freshwater prawn culture. Hard water is found to be better for prawn growth where as in muddy or turbid water growth is not good. Dike and pond slope may be kept at 2:1. Bund must have a freeboard of at least 60 cm above the highest water level in the pond. Designing and layout of the farms may be done keeping in view the water intake and water outlet facilities. The drainage system should be designed carefully to prevent mixing of outlet water with incoming water. Appropriate water supply and drainage systems have to be designed keeping in view the water source and topography of the area. Tubewell and pumping system may be considered if required for water intake/exchange. Water exchange on weekly or fortnightly basis as required is desirable and provisions are to be made accordingly.

Farm Management

The type of pond preparation to be adopted before stocking is based on the type of culture and its intensity and nature of the culture pond. Before stocking of the seeds, liming of the pond (@ 250 kg/ ha) assumes great importance here than in the case of freshwater fish culture. The application of fertilizers is restricted in case palletized feed is used. However, occasionally raw cow dung, single super phosphate; urea etc. can be applied on assessing the productivity. Mohua oil cake can be applied @ 2500 kg/ha to kill the unwanted fishes. After 8 days of liming raw cow dung applied in case of pond not treated with Mohua Oil Cake. Poultry manure @ 1000kg/ha can also be used in place of raw cow dung. After a week of organic manure treatment inorganic fertilizer (NPK) @ 20 kg/ha as basal dose should be applied before stocking of pond. If water quality found conducive stocking of freshwater prawn seeds may be done. The post stocking management also needs to fertilize the pond till the end of culture period. Each month one tenth of the basal dose of raw cow dung and inorganic fertilizer (NPK) @ 10 kg/ha is to be applied to the pond under culture with a gap of 7 to 10 days between organic and inorganic manuring. Besides this liming @ 125 to 250 kg/ha may be done for better growth of prawns as their calcium requirement is much more during moulting. Such management is required both in polyculture and monoculture of prawn. Alternatively combination of urea at 100kg and bleaching powder at 200 kg/ha can also be applied, with urea applied 18 hr before the bleaching powder application. In a newly excavated pond 5-7 tons cow dung or pig

manure and 200-500 kg lime/ha should be applied. To maintain the planktonic population in the pond, organic and inorganic fertilizers like poultry droppings, pig and cow/buffalo manure, biogas slurry etc may be applied after stocking of juveniles at periodical intervals. Urea and super phosphate should be applied in desired quantity depending on the soil and water quality of the pond. Dissolved calcium in water helps in moulting process. Therefore, after a heavy shower, Ca level in the water may decrease which is signaled by lowering of water pH. If pH decreases below 6.5, the molting process is arrested and chances of pathogen infection increased. So, it is very important to maintain Ca balance in water. For this purpose, 50 kg lime/week or 100 kg lime/fortnightly should be applied.

The stocking density normally varies from 4000 to 50000 nos. of post larvae per ha depending on the type and intensity of the management practices but it should be kept between 30,000 to 50,000 post larvae (PL)/ha under monoculture operation. But in case of juveniles (35 to 45mm) are stocked it should be @ 20,000 to 25,000/ha. If the facilities for aeration and water exchange are available, the stocking density may be increased up to 1.5 lakh/ha. The culture system may be monoculture or polyculture with carps. In case of polyculture with carps the more pond depth is preferred at 4-5 feet. In case of polyculture the stocking density of prawn may vary from 2500-20000 post larvae. The carp fingerlings may be of the order of 5000 - 2500 Nos. Prawn being detritus feeder, feeding at the bottom level on decaying matters, stocking of bottom feeder fishes such as Mrigal and Common carp may be avoided or minimized to 7% to get better prawn production. Nursery may be incorporated where the post larvae obtained from hatcheries could be reared for a period of 4-5 weeks (or 30 days) till they attain 40-50 mm or 1-3 gram.

In order to get desired production, feeding, aeration, water exchange, periodic monitoring should be continued. The quality and type of feed is based on culture system. *Macrobrachium* with its omnivorous feeding habits can make use of a variety of feeds from common wet feed made from rice bran and oil cake to scientifically formulated pelleted feed. Prawn fed with protein and calcium rich feeds grow fast and better. Crushed snails, trash fish, poultry viscera and notonectids serve as good food for them. The rate of feeding is determined by the stage of growth of prawn, water quality, density of stock and other manuring practices. Generally the feeding rate may be 5% of the body weight. Feed is given @ 10% of the total body weight of the prawns initially and reduced to 3% gradually. Feeding should be given in adequate quantity to avoid cannibalism among the prawns and thus increase their survival rate and production. Morning inspection of the culture pond should be observed everyday to assess the feed consumption and any crawling of prawn. Immediately check pH and dissolved oxygen content of water it should be optimum as mentioned below. Every month netting of prawn should be done to know the growth rate of prawn for increasing better production. Periodic harvesting of prawn should be done if prawn attains minimum 60 gms. However, desired marketable size prawn is 70 gms and above. The males grow faster and bigger than the females within the same time. There will be also differential growth of prawns which necessitates periodic harvesting to increase prawn production.

The duration of culture varies from 6 to 12 months depending on the type of culture practice. Generally in monoculture the culture period may be 6-8 months under monoculture and 8-12 months under polyculture. The average growth of prawn may range from 50g to 200g depending on the duration, density, water quality, feeding etc. The survival rate may range 50% to 70% depending on the type of management practices.

Biology

The freshwater giant prawn *Macrobrachium rosenbergii* is the most hardy and resistant species within the genera of *Macrobrachium.* It can easily tolerate different salinities of water from fresh to saltwater; therefore, this species is considered euryhaline. It lives in turbid freshwater but the larval stage requires brackishwater to survive. The animal is known for its rapid growth, with the males growing faster compared to the females. The adults are omnivorous, eat greedily and frequently on both plant and animal materials. Pieces of worms molluscs, crustaceans, cut up flesh and internal organs of fish and other animals, grains of rice, wheat, peas, beans, ground nuts, coconuts, fruits, pellets of poultry feed, etc. are items that are readily consumed. Tender stems and leaves of aquatic plants, such as *Ipomoea reptans* are also eaten when no other better food is available. When sufficiently hungry, it may even become cannibalistic. Males can reach a body size of 32 cm, females grow to 25 cm. In mating the male deposits spermatophores on the underside of the female's thorax, between the walking legs. The female then extrudes eggs, which pass through the spermatophores. The female carries the fertilized eggs with her until they hatch; the time may vary, but is generally less than 3 weeks. A large female may lay

up to 1000,000 eggs. From these eggs hatch zoeae, the first larval stage of crustaceans. They go through the eleven larval stages before metamorphosing into post larvae, at which stage they are about 8 mm long and have all the characteristics of adults. This metamorphosis usually takes place about 32 to 35 days after hatching. These post larvae then migrate back to freshwater. There are 3 different morphotypes of males. The first stage is called "small male" (SM); this smallest stage has short, nearly transluscent claws. If conditions allow, small males grow and metamorphose into "orange claws" (OC), which have large orange claws on their second chelipeds, which may have a length of 0.8 to 1.4 their body size. OC males later may transform into the third and final stage, the "blue claw" (BC) males. These have blue claws, and their second chelipeds may become twice as long as their body. Male rosenbergii have a strict hierarchy: the territorial BC males dominate the OCs, which in turn dominate the SMs. The presence of BC males inhibits the growth of SMs and delays the metamorphosis of OCs into BCs; an OC will keep growing until it is larger than the largest BC male in its neighbourhood before transforming. All three male stages are sexually active though, and females who have undergone their premating moult will cooperate with any male to reproduce. BC males protect the female until their shell has hardened, OCs and SMs show no such behaviour.

Food materials are located mainly by the sense of smell and touch. When searching for food the first and second pair of the thoracic legs which are chelate sweep about actively. The prawn is usually quiet during day time and stays at the bottom of waters without much active locomotion and tends to avoid strong illumination. They are active at night time, searching for food. When mature, male prawns are considerably larger than females. The second thoracic legs are extremely long and rather thick, the head is big, the abdomen compact with very little space between the pleura, and the genital pores are at the base of the fifth thoracic legs. Females are generally smaller than the males, the second thoracic legs are shorter and more slender and the head is smaller. There is a spacious brood chamber below the abdomen, formed by the downward prolongation of abdominal pleura, and genital pores are at the bases of the third thoracic legs. The ripe ovaries can be seen through the carapace as large orange coloured masses occupying a large portion of the dorsal and lateral parts of the cephalothorax. Sexually mature males are able to mate at any time, while the females are ready to respond only after completing their premating moult.

The moulting that takes place shortly before mating or spawning is called premating or prespawning moult, to differentiate from the ordinary moulting. The frequency of moulting depends on the age, availability of food, quality of food, and also is affected by the water quality. Young specimens moult more frequent than old ones. Animals obtaining enough and good quality of food moult sooner than those taking less or poorer food. Females with actively developing gonads getting ready for spawning, take longer period to moult. Ordinarily the interval between two moults is 20–40 days. Newly moulted specimens are weak and vulnerable to predation. It takes 2–6 hours for the new shell to become sufficiently hardened.

A large number of species of *Macrobrachium* which includes *M. rosenbergii* is known that they reach sexual maturity long before attaining their maximum size. Under tropical conditions, mating occurs throughout the year within 6–20 hours after mating the eggs are laid; and unmated ripe females may lay eggs within 24 hours but the eggs are not fertilized and drop off in two or three days. The laying of one whole batch of eggs is usually completed within 20 minutes where the eggs are extruded through the female genital pores into the brood chambers. Fertilized eggs will hatch in approximately 18–21 days during incubation period. The number of eggs produced by each individual female depends upon the size of the specimen. Some workers estimated the number of eggs varies from 800–1000 per 1 gram of body weight. But practices show it is easier to estimate the number of newly hatched larvae rather than the number of eggs. From the time of hatching to the juvenile stage, the development of larvae takes 30–45 days through a series of metamorphosis (stages), all larval stages require brackishwater to grow which corresponds to at least 5% seawater. Specimens which live in pure freshwater and fail to reach brackishwater within 4–5 days would not be able to survive. They are planktonic in habit and are active swimmers whereas during the early stages, they tend to move around close together in large groups, usually close to the surface of the water. This milling together disappears in about 10 days. Their swimming position is peculiar, tail first, ventral side up with the head lower than the tail.

The larvae are attracted by light, but direct sunlight and other strong lights are avoided, and through the whole larval stages they eat continuously as long as food is available in the form of living food and suspended particles of suitable sizes. As soon as the larvae metamorphose from the last larval stage, they

Fig. 1: Diagrammatic view of the external features ofGiant FreshwaterPrawn (*M. rosenbergii*)

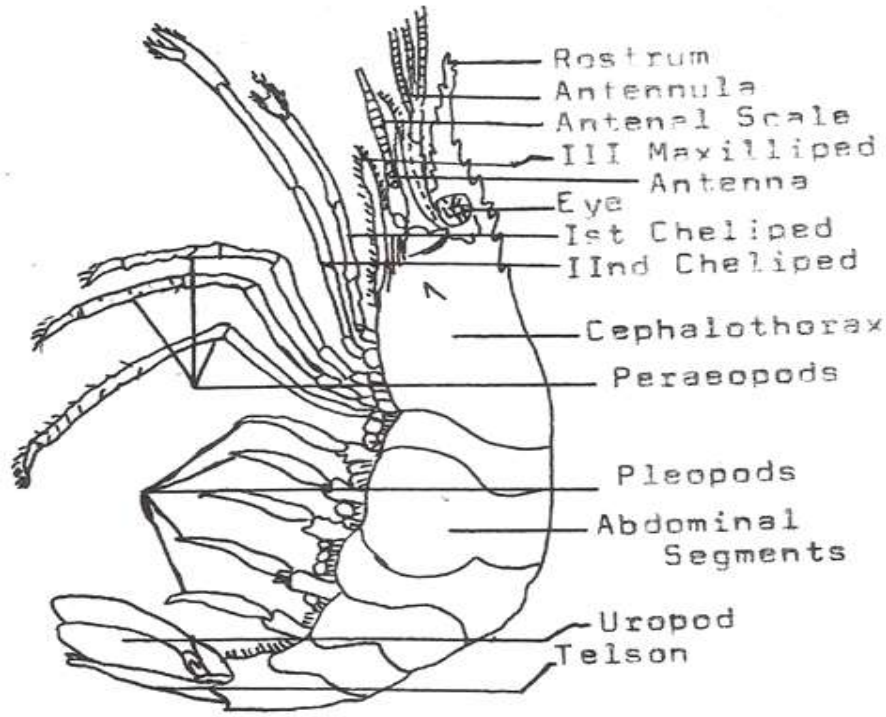

Fig. 3: Harvesting of Freshwater prawn (*M. rosenbergii*) from farmer's fish pond in Punjab

cease to be planktonic or pelagic. They settle to the bottom as crawlers or attach themselves to vegetation and submerged objects as juveniles. Under natural conditions, these newly transformed juveniles still remain in brackishwater for several weeks before starting the migration upstream towards freshwater for their wide dispersion. They feed on tiny worms, small crustaceans, insect larvae and a variety of organic materials. In good environmental conditions, they can attain about 5 cm in two months and can survive wide temperature ranges.

Characteristic of Adults

Among adults the male prawn is much bigger than the female. Males can reach a body size of 32 cm, females grow to 25 cm. It is differentiated by a pair of long and rather thick second thoracic legs which is the pincer. It has a very prominent head and compact abdomen with very little space between its pleura. A genital pore is present at the base of its fifth thoracic legs. A female is comparatively smaller than a male with shorter and slender second thoracic legs, a medium head and a spacious brood chamber. The genital pores are located at the base of its third thoracic legs. When the female is sexually ripe the fully developed ovaries can be seen through the carapace. It is a large orange mass occupying a large portion of the dorsal and lateral parts of the cephalothorax. The swimmerets become slightly distended and arched outward to form a large "brood chamber" to accommodate the enormous number of eggs to be laid. The basal segments of the pleopods, particularly those of the first three pairs are elongated and are equipped with much branched setae on their inner margins which are developed during spawning to accommodate the eggs which are attached in bundles to this setae through an adhesive substance as the eggs are extruded.

Growth and Moulting

The entire body of the prawn is covered by hard chitinous shell that is periodically shed out during metamorphosis, which is called moulting. Metamorphosis occurs at each stage of larval development. During metamorphosis from zoea I to post larvae the process of moulting occurs 10 times or more in all the 3 large size freshwater prawn. Generally among arthropods, the body is usually covered with hard chitinous coating known as the exoskeleton. This hardened integument is a good protection of the body of the animal. However, like other crustaceans it prevents the expansion of the body. Hence, the shedding of the exoskeleton or moulting becomes a necessity in order to institute growth. As a natural process when the animal has accumulated enough body tissues, body expansion becomes inevitable. At this process, a new thin, soft and elastic sheet is developed gradually but steadily immediately underneath the old hard exoskeleton. When the new coating is fully developed, the animal becomes quiet and tries to separate and seclude itself from the others to shed off the old hard shell. As soon as the old shell is shedded, the new shell which is soft and elastic expand due to pressure emanating from the accumulated mass of body tissue. This body expansion is actually the unit of growth which periodically has to take place in the animal in the process of growing. Just after the old shell is shaken off, the animal is very soft. It takes hours before it is hard enough for the prawn to resume its normal active life. During the time that the shell is soft, the animal is immobile and helpless when attacked by predators. This is probably the reason why the animal secludes itself during moulting.

The casting off the old shell is rapidly accomplished in a matter of minutes. The prawn try to bend its body to exert strong internal pressure until a dorsal transverse split occur in the membranous part between the cephalothorax and the abdomen. Then the animal bend its abdomen ventrally forming an inverted "U" shape arc dorsally, until a portion of the body is out through the split dorsal opening. As the abdomen gets rid of its cast, it bends anteriorly to facilitate the release of the exuvium of the cephalothorax. In the process, it is possible that a longitudinal split along the sides of some segments of the large thoracic appendages also occur to ease the withdrawal of the new limbs. The frequency of moulting depends largely on the quality and quantity of food taken. And like any other organism, growth rate is faster at younger stages and gradually slows down as the animal gets older. Hence, moulting is more frequent when the prawns are young.

Breeding Behaviour

Mature male prawns are always ready for copulation. They can perform intercourse whenever the female is ready. On the other hand, the female have to be in a certain stage/condition in order to be able to mate.Mating cannot be performed if the exoskeleton of the female is hard. Therefore, to consumate the act the female have to undergo a premating moulting. It will take only a few hours before the new shell hardens, hence, it is necessary that mating should take place at certain precise state of the shell. It should not be too soft nor too hard.

When it is too soft, the male is liable to devour the female. If the shell becomes fully hardened, mating may not be effectively performed or no mating occurs.In other words, the female has to prepare itself for a "love" affair every time she is ready to spawn in order to fertilize the eggs and young ones are borned.

How does the male know that the female is undergoing a premating moulting as differentiated from ordinary growth moulting? The female releases certain kind of substance to attract the male during premating moulting. When the male notices this, then it immediately starts courting the female instead of devouring it. It will display its masculine grace and strength by lifting its head, raising its body, waving its feelers and raising and extending its long and powerful thoracic legs in an embracing manner with intermittent jerking movements until the females favour is won.

Upon agreement the male holds the female between its pair of long thoracic legs at the same time cleaning the ventral portion of her shells in the thoracic region with its other legs. This is followed immediately by the actual copulation which takes only a few seconds like a lightning. The sperm is deposited in one mass on the ventral thoracic region between her thoracic legs. The sperm is coated with thin layer of gelatinous substance for protection and to keep them intact.

Egg-laying (Spawning)

Whether the female is mated or not, it will lay eggs in about 24 hours following the premating moulting. During the ejaculation of the eggs, the mother prawn bends its abdomen forward as far as it could reach to touch the ventral thoracic region. The eggs which are extruded through the genital pores are directed into the "brood chamber". They are held together by some extremely thin and membranous substance and are deposited first on one side, starting on the chamber between the fourth pair of pleopods and so on to the third, second, and finally to the first. The eggs are held in bundle tightly to the fine ovigarous setae of the first four pairs of pleopods and look like bunch of grapes. The female carries these eggs till they hatch out and such egg bearing females are called "berried". The number of eggs carried by the female is based on its size and weight, which ranged between 8,000 to 1,50,000. A mature female will breed and spawn 3-4 times in a year under natural freshwater environment.

Incubation and Embryonic Development

The eggs, like bunches of berries in the brood chamber are carried by the brood during the whole incubation period which lasts approximately 18–21 days, depending on temperature of 26 to 31 C. During the incubation period, the mother prawn moves the pleopods back and forth intermittently to provide sufficient aeration to the eggs. In the meantime, the first pair of the thoracic legs is busy cleaning the eggs of any foreign matter.

Embryonic development immediately starts as soon as the eggs are extruded. The first nuclear division will be observed about 4 hours after fertilization. The cleavage is completed in about 24 hours. Rudiments of the body region of the embryo will be visible on the third day and appendages will be formed on the fourth day. The eye pigment starts appearing at the end of the eight day. The heart is formed and start beating on the tenth day. The embryo is actually formed on the twelfth day which is subsequently followed by the larvae development on the seventeenth day. Midway of the embryonic development period, the egg orange pigmentation turns light gray to dark gray as the embryo is further developed until it hatches.

Hatching Process

The breaking of the eggs is accomplished by a slow but continuous vibration of the mouthparts of the larvae, coupled with the stretching of the rolled up body forcing the eggs to elongate gradually. As these mouthparts vibration and body stretching increase its force, these are reinforced by the intermittent vigorous vibration of the thoracic appendages for about 10 minutes with increasing intensity. This continuing and increasing force is soon accompanied by the stretching of the telson outward until the egg shell breaks up and the telson thrushes out first followed by the head and with strong body bending and stretching the larva springs out of the egg case.

Larvae and Juveniles

The newly hatched larvae which are devoid of many segments and appendages of the adult start swimming in about 5 minutes after coming out of the egg shell. At this point in time, the water must be brackish. The minute and fragile larvae have no semblance to their parents. While they are attracted

by light, they avoid strong illumination and direct sunlight. During the entire larval stages, they remain pelagic and actively swim around upside down grasping their food as they come across. They are voracious feeder and will eat continuously as long as food is available. The food consists of zooplankton such as copepods, minute protozoans, rotifers, cyclops and pieces of animal flesh, food grains, fruits, etc. The food is grasp by their thoracic legs as they swim. There are about 13 larval stages. These development stages from hatching up to final metamorphosis is completed in about 45 days. Obviously growth rate is influenced by water temperature and quality of food. You may observe that fast growing individual larvae may complete metamorphosis in less than 25 days.

As soon as the larvae metamorphose, they lose their pelagic characteristics and become bottom crawlers or cling to submerged objects such as leaves, roots, stems and branches of aquatic and semi-aquatic vegetation. This time they feed greedily on aquatic worms, bottom insects and larvae, fish eggs, tiny fry or other aquatic animals, algae, and particles of organic materials including some epiphytes.The larval transformation to post larval stage marks also the end of their life in brackishwater. From this stage on, they start their positive rheotrophic migration. They swim against swift currents by tightly crawling on the bottom. They can migrate up to inland lakes and dams passing along sides/edges/embankments of streams. During flood seasons, they further move upward to rice fields, small lagoons and freshwater ponds which are not accessible during dry season. From the beginning of their upstream migration up to their adulthood, the prawns stay in the freshwater as their permanent abode.

Sexual Maturity

The female prawn attained its first sexual maturity on the tenth month when they are about 12 cm or more in length. A sexually matured female will develop the gonads and will lay eggs whether it is mated or not. However, the eggs of unmated female will fall off in a few days as such eggs would not hatch. Some females were observed to spawn twice in four months under controlled condition. The number of spawning per female per year in the natural habitat is yet to be further observed. It can be assumed under natural conditions that as the female develop its gonad it starts its negative rheotrophic migration. Somewhere along the way, it undergoes premating moulting and gets mated. At this point, it should reach tidal lagoons or mouths of tidal rivers where water remain brackish all the time for the hatching of the eggs and subsequent development of the larvae. If the mother prawn fails to reach the brackishwater area in this journey the young larvae will die within three to four days after hatching.Some studies on the fecundity of the giant prawn showed that they have quite high reproductive capacity. A female of about 17.2 cm long weighing about 65 g can produce about 90 000 eggs. Large females are assumed to be able to produce a lot more. Brown (1991) reported fecundity can be as high as 80,000 to 1,00,000 eggs in mature females while first broodstock may be around 5,000 to 20,000 eggs. Ratnayake*et al.,* (2001) revealed fecundity ranging from 24171 to 34294 in *M. rosenbergii* reared under varied sex ratio in Sri Lanka. Fujimura, preliminary established a weight/number relationship in estimating the fecundity of female prawn. The total number of eggs is estimated by multiplying the total weight of the spawner in grams by 750.

Migration

Movement of the prawn chiefly migration, like any other aquatic fauna is influenced by many factors mainly physical, chemical and biological stimuli. While the positive and negative rheotrophic migration of the prawn to complete its life cycle may be a natural instinct, it is quite obvious that it may be associated with chemical stimulus. The desire to hatch and grow the young larvae in a brackishwater to perpetuate its kind requires the prawn to perform the journey. Perhaps temperature also plays an important role since the water is warmer in the coastal areas than upstream.

Food and Feeding Habit

The giant prawn is an omnivore, bottom dwelling animal and feed greedily. In nature, they feed upon young molluscs, crustaceans, small worms, decomposed plant and animals, flesh of both aquatic and terrestrial animals, grains, nuts, beans, coconut meat, pieces of some fruits, etc. Actually they are also cannibalistic since they devour their own kind when they encounter soft shelled individual except perhaps when they are in a premating moulting when the female is guarded by the male. They continue to crawl on the bottom in search for food or cling on submerged vegetation including those along embankments of rivers or lakes or impoundment or among hanging roots of floating aquatic plants such as the water hyacinth. They can be observed also nibbling epiphytes among submerged twigs and branches. Unlike fishes, they do not take feed directly into the mouth; rather, they break the feed into small

pieces with the help of mandibles and then take into the mouth. Since they are cannibalistic in nature, under starved condition, they attack the newly molted and weak members of their own species or other animals and feed on them.

Feeding Practices

The production capacity of culture pond largely depends on quality of feed provided. The grow out feed should contain 30-40% crude protein, out of which 50% should be from animal origin. The different feed ingredients are mixed in desired proportion and prepared as pellet, and provided to the prawns to avoid the wastage of feed. Locally available feed ingredients like rice bran, mustard oil cake, groundnut oil cake, coconut oil cake, soyabean meal, maize, sorghum, barley and other ingredients obtain from plant are used. Besides fish meal, the other ingredients of animal origin evaluated for incorporation in the feed are poultry viscera, slaughter house waste, small prawns, fishes, mussel or snail meat etc. Along with these feed materials, vitamin and mineral mixture in desired quantity are added to help the prawn to overcome environmental stress. Now a day farmer's are using pelleted scampi feed of Godrej Agrovet Ltd and chicken viscera for feeding prawn and getting desired result.

For grow out culture of prawns feed are initially given at 5-8% of the body weight/day. The feeding rates decline as the animals grow and reach about 1.5 – 2% bwd when the animals are about 20 g in size. Broodstock are fed with balanced artificial formulated pelleted feed at 3-5% of the body weight twice daily during morning and evening. Farmers generally feed the cultured prawn twice daily with feeds that contain protein levels ranging from 20 to 35%. However the species grows well even with 15% protein feeds in ponds with sufficient natural food (Mitra *et al* 2005).

Nutrients	Growth stages	Requirements
Protein (%)	Broodstock	38-40
	Juveniles (2^{nd} 4^{th} month)	35-37
	Adult (5^{th} 6^{th} month)	28-30
Carbohydrate (%)	For all stages	25-35
Lipid including phospholipids (%)	For all stages	3-7
High unsaturated fatty acids (%)		>0.08
Cholesterol (%)	For all stages	0.5-0.6
Vitamin –C (mg/kg diet)	Grow out	100
Calcium/Phosphorus		1.5-2.0:1
Zn (mg/kg diet)		90
Other minerals		Quantitative requirements not yet known
Energy	Broodstock	3.7- 4.0 kcal/g feed
	Other stages	2.9- 3.2 kcal/g feed

The summary of nutrient requirements of freshwater prawn, *M. rosenbergii* based on laboratory trials are depicted in following table (Mitra *et al* 2005).

General conditions of soil and water quality for culture

The ideal soil for *Macrobrachium* culture should be clay silt mixture or sandy loam (Sandy-clay, Sandy–loam, Silty-clay or Silty-loam) comprising of 60% sand and 40% silt with good water retention capacity. Soil should be alkaline and fused lime can be applied to make the soil fertile before stocking of prawn. Lime should be applied @ 2-4 tonnes/ha. Acidic soils (pH = 4.5 or less) with high concentration of iron, Manganese, Aluminium are to be avoided. There should be availability of abundant and good quality water. The water should be free from any kind of pollution. The pH should be maintained at 7 to 8.5. The temperature should range from 18 ^{o}C to 34 ^{o}C with an optimum range of 26 ^{o}C to 32 ^{o}C. Dissolved oxygen content in water should not be less than 2.5 ppm. The concentration of dissolved oxygen in water can be raised by provision of aerator. To maintain O_2 level in water, water depth in pond should be maintained and aquatic plant should be kept within certain limit. Water exchange may be done periodically to remove the excretory products from the pond. Water quality parameters should be analyzed periodically and if required lime treatment should be done.

Water Temperature	:	26 ^{o}C to 32 ^{o}C
pH	:	7.0 to 8.5
Dissolved Oxygen	:	> 2.5 mg/l
Total Hardness	:	100 to 150 mg/l
NH_4^+ –N	:	0.02 to 0.20 mg/l
Calcium	:	30 to 80 mg/l
Phosphorus	:	0.01 to 0.9 mg/l
Nitrogen	:	0.05 to 0.5 mg/l

Marketing

There is good demand for fresh water prawn in local, national and international markets; as such there may not be any problem in marketing the same because it is used to maintain fairly stable market price. It has been stimulated by the increasing market demand and high economic return in production. Fresh water prawns can be sold directly by the farmers either in the market or to exporters for processing before export. Weight of *M. rosenbergii* up to 50 g can fetch Rs 300/- per kg whereas more than 100g cost Rs 400/- to 600/- per kg during harvesting season. Marketing of freshwater prawn in Punjab have many options such as selling to wholesaler, market to local consumer, hotels, restaurant, pizza hut or become a processor so that extended marketing time avail. Selling to wholesaler is easy but when low production noticed, a considerable profit may not be felt. Local marketing requires expenditure in advertisement and the timing of harvest to selling is critical, because freshwater prawns are very sensitive perishable items. To ensure the compliance with government regulations processing of freshwater prawns and processors requires obtaining training and certification in hazard analysis critical control point (HACCP). Cultured freshwater prawn production in Punjab still accounts for a small proportion of the total freshwater aquaculture production in India. However, the rapid growth in production caused by the expansion of culture has significant impacts on the marketing and economic return of the industry.

Hatchery Management

Hatchery should be located in such a place where pollution free freshwater, sea water, healthy and disease free brood prawns, feed ingredients for supplementary food, uninterrupted power supply, hatchery workers, road for transport, required environmental condition etc are available. It is essential to have a detailed plan for establishment of a hatchery, which would largely depend upon the production target. Accordingly, different capacity of larval rearing tanks and water filtration tanks, rooms for laboratory, food preparation, Artemia hatching, storeroom etc are provided.

Following points should be thoroughly studied before starting hatchery management

- Freshwater and seawater requirement with desired characteristics
- Broodstock management
- Larval rearing
- Airlift biofilter recirculatory system
- Water quality management
- Larval feed
- Hatching of Artemia cysts
- Supplementary feeding
- Moulting and growth
- Disease diagnosis and control
- Harvesting of post larvae
- Rearing of post larvae in nursery
- Seed transportation
- Grow-out culture

Constraints and Problems

- Fish farming being an alternative enterprise, the farmers of Punjab have not lagged in adopting fish culture where the area under fish farming increased ten folds compare to the past. In spite of this the various groups are facing some constraints in the production and marketing of fish/prawn.
- Prawn farming in Punjab is economically feasible but the major constraints for the development of prawn farming is the lack of hatchery seed and the need to disseminate the necessary technology to the private sector. The establishment of a small government hatchery, together with facilities to rear post larval prawns (PL/juveniles) to a suitable stocking size, and the ability to demonstrate grow-out technology, is critical to the development of commercial prawn culture in the state.
- The commercial rate of electricity charges is a major constraint in aquaculture development in the state. Fish farmers need to be provided free electricity like agriculture farmers. Inadequate and untimely supply of credit, lack of proper technical guidance on prawn farming and lack of proper marketing and storage facilities is problem for middle level fish farmer.
- The growth and development of freshwater prawn is temperature dependent so only one crop (April to October) can be harvested in Punjab which impediments in the adoption of prawn farming. The farming solution throughout the year may be chalked out and suggested.

- Unavailability of good quality freshwater prawn seeds and monosex seed (male) lowering the seed survival rate in the pond.
- The cost of freshwater prawn seed and its import is very costly. Govt. owned/ private Prawn hatchery could not established in Punjab.
- Farmers are facing the problems of theft and poaching. High price and ready market attract the poachers easily. Prawn has resistant to diseases, but a heavy stocking density, over manuring, non-maintenance of clean environment, accumulation of organic matter at the bottom of the pond cause many hazards to the health of the species. These hazards include retarded growth injuries, diseases and parasitic infections that adversely affect the production.
- During the course of culture operations a few insect and pest are encountered which sometimes cause heavy mortality to the young stock. These insect and pest include aquatic insects, predatory and weed fishes, frogs etc which reduce the fish production to a large extent.
- One of the major problems in fish ponds was found to be the control of excessive growth of aquatic weeds. Though the presence of some plants to a limited extent is desirable, yet their excessive growth affects the prawn productivity per unit of the area stocked.
- Being an outdoor enterprise it is prone to damages by animals like snakes, tortoises and flooding during the rainy season.
- Operation of cast net is not effective to catch all the prawns, also cast net needs multiple operation and more effort, because prawn lives in bottom of the pond, so the pond should be drained out to harvest prawn crop and dispose immediately to middlemen or market consumer.
- The problems in the disposal of prawn/fish and delayed payment of the crops were also reported by the farmers and the middlemen. The time lag between the delivery of prawn and payment was reported to be sometimes more than two months. No compensation for the delayed period noticed.
- Prawn/fish producer and middlemen faced lower price for their crop. They are being forced to sale the produce at lower prices due to lack of steady marketing outlets. Also, there are very few buyers in Chandigarh so the producer forced to spend time in searching prawn consumer to sale the catch and even some of the buyer asked to provide headless prawn.
- Punjab farmers engaged himself in fish culture in a more amicable and eco-friendly way compare to other states of India, but majority of the people in Punjab are not in fond of eating fish as well as prawn due to spine and unusual looks.
- The lack of an efficient storage, insulated/ thermostat van, packing and transportation facilities, quickness in the decomposition of the produce resulting into increased losses.
- The middlemen are forced to dispose of produce quickly otherwise decaying of the prawn/fish starts which in turn lower the price of the crop.
- Prawn/fish marketing is not controlled by the Govt. agency, therefore the malpractices such as lower price during the increased volume or market arrivals.
- Major problem in the sale of prawn/fish is the peculiar odours after death of prawn which affects the demand in local markets.

The aforesaid problem clearly exhibits that prawn farming is affected on various accounts, which ultimately affects the production levels. Under these situations, there is a need to formulate basic guidelines to make prawn farming/enterprise commercially viable in Punjab.

Management and Precaution for successful freshwater prawn farming

- Prawn production is increased by obtaining juveniles of nearly the same size. If widely different sized juveniles are obtained, survival in the early days after stocking into ponds may be low since larger prawns will eat the smaller ones and smaller prawns may be nutritionally challenged and less able to survive.
- Separate size groups into different ponds as variability of more than 0.5" between the large and small juveniles in this trial caused low survival due to cannibalism.
- Zooplanktons provide the best food source for small prawns. The pond should be conditioned with inorganic and organic fertilizer until a bloom of zooplankton and phytoplankton develops.
- No prawns should be stocked if the pond water is clear.
- The timing of prawn stocking should be carefully managed so that the pond does not remain filled for more than two weeks prior to stocking.

- A food supply will develop as the fertilizer stimulates phytoplankton and zooplankton growth. With an adequate food supply, the prawns are expected to grow fast enough to be safe from all but the largest predators.
- Prawns do not really like light and will inhabit the deeper portions of the pond. If weeds and filamentous algae become established, chemical treatment should be avoided. If weeds are allowed to grow, prawn production will be lower than expected and harvest will be difficult.
- Aquashade and other water soluble dyes may reduce the amount of primary productivity in ponds and therefore reduce prawn production by reducing the amount of natural food organisms. Grass carp may eat some of the young prawns so that prawn survival may be less when the generally herbivorous fish is stocked with prawns. Culture systems using catfish and prawns or carps and prawn have been proposed but in all cases of polyculture, the prawn production is reduced from that obtainable in monoculture.
- During the time between stocking juveniles and the time that feed is first offered to the prawns, ponds are managed to produce zooplankton that will serve as the food for the young prawns. Organic fertilizer added at the rate of about 50 kg/ha/wk can produce abundant zooplankton populations. Inorganic fertilizers that have nitrogen and phosphorus should be added until a phytoplankton bloom develops in the water. The visibility into the water column should be less than 18 inch in a properly fertilized pond. Add 3.5 to 5 kg/ha/wk of phosphorus in order to maintain a good bloom.
- The lime requirement for the pond must have been considered before the pond was filled with water in order for a fertilization program to be effective. The optimum growth of prawn depends upon the pond soil, which should be alkaline. Fused lime can be applied to make the soil fertile. The agriculture grade lime should be applied @ 2-4 tonnes/ha in properly ploughed pond bottom before stocking of prawn.
- Phytoplankton and zooplankton blooms can be started rapidly when water from a reservoir or adjacent pond is used to fill the prawn pond. Addition of fertilizer to pond water that already contains relatively large quantities of microorganisms causes rapid increases in numbers. This practice should be encouraged in prawn culture in order to assure an abundant food supply for the young prawns and shade for the pond bottom to discourage aquatic weed growth. All incoming water should pass through a screen that is small enough to retain fish eggs, small fish, and insects. Ponds should be stocked with the prawns between one to two weeks after the pond is filled.
- The concentration of dissolved oxygen in water should not be less than 2.5 ppm. Uniform dissolved oxygen of the pond water can be raised by the application of aerator using blower, pipe and pierced stone.
- The concentration of ammonia and production of H_2S may increase due to decomposition of organic matter. Necessary liming and water exchange may be done to keep their conc. within critical limit.
- Feeds and feeding gradually change from a fertilization schedule to feeding a slow sink pellet. Common agricultural byproducts such as cottonseed meal and distillers grains may be utilized to feed the prawns during the first two months of grow-out. However, during the last 30 to 60 days of production, a pellet may be utilized. Scatter the feed as evenly over the pond bottom as possible. Narrow pond designs are common in prawn culture in order to allow easy feed application. Prawns use natural food to supplement the diet provided, so a very complete diet must be provided in plastic lined ponds or tanks. Godrej Agrovet has already prepared Scampi feed which can be utilized to feed prawn.
- Harvesting prawns can be similar to seining other aquatic animals but it is difficult to harvest prawn through simple drag net. A special net like seine with ½ inch mesh size using glass beads or iron weights at its bottom to make pockets can be utilized for harvesting prawn. Once the prawns were collected, the large prawns were sorted from the small ones with a bar grader and by hand picking. Small prawns (less than 45g) were returned to the pond for 30 days or more of additional growth. Removal of the large blue claw prawns allows other prawns to grow to a larger size. Prawns require oxygenated water to survive, so plenty of aeration should be utilized when harvesting. Provide a substrate in the holding tanks if you want to keep the harvested prawns alive. The substrate will allow prawns to seek refuge from their aggressive companions. Prawns jump considerable distances so that a cover should be placed over the holding tank

immediately after it is filled. To preserve the best appearance of the large blue claw males, close their claws with a small rubber band prior to holding in tanks. Water temperatures, 20 to 25 ^{o}C, slow the prawns down so that they are less aggressive.

- The final harvest of prawns should occur before pond water temperatures fall below 22 ^{o}C. The giant prawn is a tropical to sub-tropical animal and has slow growth at low temperatures. Little or no growth is expected when water temperature is less than 26 ^{o}C. Indoor culture of the prawn is difficult and requires a great investment in tanks, filters, and electricity. Only the hatchery and nursery phases are practical for indoor culture of prawns.
- Monoculture of prawn can be done amicably from April to October where as polyculture of carp during rest of the months in order to utilize resources and time interval for gaining maximum output.
- Prawns after death deteriorates faster and gives bad odour compared to fish, so it is necessary to keep them in ice just after harvesting or quickly transport to processing plant.
- It is important that the government facilities should not be much larger than needed. The adequate demonstration of nursery and grow-out technology, for providing a small income to the farmers, and for producing post larvae and juveniles for supply to the private sector to stimulate the development of prawn farming.
- Good quality of freshwater prawn seeds (acclimatized seeds in nursery pond with good size) should made accessible for stocking in fish farmer's pond so that survival of the prawn seeds attains to be maximum.
- The cost of freshwater prawn seed (PL/juveniles) and its import should be available at cheaper rate. Govt. should provide prawn seed to farmers on subsidized rate and establish freshwater prawn hatchery in Punjab to fulfill the urgent need of the fish farmers.
- The facilities should therefore be designed to produce sufficient post larval prawns to stock nursery ponds for the production of enough juveniles to supply the requirements of private farmers wishing to stock up to 10 ha of ponds at 5 juveniles per m^2. The hatchery should also produce enough stock to provide service to the farmers, grow-out demonstration and training activities. The demonstration ponds should also produce marketable prawns annually.
- State Govt. should also try to motivate the riparian farmer's in adoption of freshwater prawn culture in unutilized saline affected water-logged areas (1.72 lakh ha) in south-west district of Punjab, for this it is necessary to provide incentives/subsidy for the utilization of resources and improving economic condition of the region.

Conclusion

Freshwater aquaculture over recent years has not only led to substantial socio-economic benefits such as increased nutritional levels, income, employment and foreign exchange but has also brought vast un-utilized and under-utilized land and water resources under culture. With freshwater aquaculture being compatible with other farming systems it is largely environmentally friendly and provides for recycling and utilization of several types of organic wastes. Over the years, however, culture practices have undergone considerable intensification and with the possibility of obtaining high productivity levels.

Prawn culture appears to be economically viable and has great potentiality in India. But technologies for semi-intensive culture of freshwater prawns are yet to be developed in Punjab. Initially extensive culture in a scientific line is required to be popularized to exploit the existing potential areas at an optimum level. It is also very important to aware the farmers about the source of seed supply for appropriate pond stocking. Therefore, before bankers consider financial support for any *Macrobrachium rosenbergii* culture operation, they should see that seed supply is assured and prawn hatchery establishment and feed development get priority over prawn farming. Prawn production requires careful management and is hindered by a general lack of technical information, particularly the proper use of chemicals for water quality control and weed control. The evaluation of prawn production in Punjab may continue for one more season to find out the percentage survival and adaptability of the species. Variable juvenile size and quality, variable food supply, and pH control may be most important in determining prawn yields. There is need to use quality seed, balanced feed and

scientific management practices for successful prawn farming.

In fact prawn farming is a profitable venture, a farmer can earn more than Rs 70,000/- per hectare per year from prawn farming, compared to Rs 25,000/- per hectare from wheat or rice. Now, there is a need to popularize the technology for adoption and diversification among farmers through mass awareness programme. The reasons for the adoption and expansion include less risk and ease of marketing over traditional agriculture activities and, of course, greater returns.

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[9] National Statistics Online—Trends in suicide by method in England and Wales, 1979-2001. www.statistics.gov.uk/downloads/theme_health/HSQ 20.pdf (accessed Jan 24, 2005): 7-18. Only verified references against the original documents should be cited. Authors are responsible for the accuracy and completeness of their references and for correct text citation. The number of reference should be kept limited to 20 in case of major communications and 10 for short communications.

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