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Logo Description : It symbolizes an elephant within an ecological frame of peace and harmony moving towards prosperity and posterity. **Cover photo** (Anticlockwise from top) ; 1. An isolated vulture signaling the population crash. 2. Growth parameter of capitulum of a sunflower 3. Farmers' practice of growing sunflower 4. A spotted deer under surgicare. **Cover background photo** : A spotted deer browsing in thickets of Similipal (Photo by B.Mohanty)

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EDITORIAL

Water and soil are two natural resources of earth. In the process of climate change, both the resources are either over-utilized or mismanaged. In the sub-continent, we are unable to manage both soil and water properly. The water what we see all around us happens to come from rain water. It is being trapped in rivers, ponds, natural reservoirs or in major dam projects. Since inception of five year plans, government has spent a huge amount on irrigation sector. Now, it has been reported that 35% cultivable lands are irrigated. The rest 65% lands remain rainfed. Seeing the irrigation potentialty, independent India has experienced many small and big dam projects. But there seems to be a huge gap between irrigation potentialty created and irrigation projects being in operation. To add to it, farmers are not well aware of the best management of soil and water. We know, top soil(9" to 1') is fertile. In Indian conditions farmers are not able to preserve their top soil. Once, there is loss of top soil, the fertility of land decreases hampering the production. In rainy season, the water is rolled down with the soil to no man's zone. In some cases the natural passage of streams and rivers are blocked. The main reason is that most of the lands are not surrounded by bunds. To retain the top soil, one needs to give a bund height of 1'-1.5' in normal lands and in slopy lands 1.5'-2'. The bunds are not permanent structures. Those are to be repaired and reconstructed each year. Hence, bund management is highly necessary to save rain water and the soil. During heavy rains, water overtops bunds 4-5 times a year. These can be arrested with scientific approach. In the slopy land, particularly in hilly regions, terracing measures help in retaining top soil. In forests, water bodies dried up. The main reason is that; rain water constantly carry top soil to downward and in the process waterbodies slowly filled up with silt. That comes to a level where it cannot retain water. The water is drained down. Lack of water bodies in forests affect the wildlife health and enrichment of overall forest ecosystem.

The ground water is having its own limitations. Hence, we have to think of saving the rain water. Over exploitation of ground water for domestic as well as industrial purposes has reached to such an extent that there is possibility of non-availability of this precious natural resource after a few decades. Hence, instead of ground water, we have to give more stress to surface water management and rain water conservation. Now, government has planned to promote rain water conservation through roof top rain water collection within coming 5 years. Under roof top harvesting management, provision has been made to subsidize the scheme. Rain water after 3rd shower onwards has been reported to be clean and can be stored further to be used as drinking water. If we can collect it from the roof top, we can save the energy to a substantial level. Non-government organizations and the general public should come forward to support these schemes so that soil and water be better managed.

(Dr. R. K. Samantaray)
Editor-in-Chief

VALUATION OF CO_2 SEQUESTRATION IN PUBLIC PLANTATIONS AND COMMUNITY PLANTED FORESTS IN TARAI, NEPAL

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ABSTRACT

Reducing Emission from Deforestation and Forest Degradation (REDD+) reward needs comprehensive records of carbon stock change, thus, this research has focus to assess and compare the current annual carbon increment in public plantations and community planted forests and their current annual CO_2 sequestration and finally to estimate the monetary value of CO_2 sequestration in these plantations. Records of three consecutive years were taken applying random sampling from three public plantations and three community planted forests of Mahottari district. Altogether 55 samples were taken using the Geographical Positioning System (GPS). Biomass of poles and sapling were estimated using equation given by Chave*et al.* and dried biomass of seedling, grasses and litter were determined from the lab and converted into carbon. Lastly current annual carbon increment (CACI) and CO_2 sequestration were calculated and their values were determined. The estimated CACI recorded the highest 6.56 t ha^{-1} at the third year in Shreepur public plantation (PP) but it was the lowest 1.02 t ha^{-1} in Ramnagar community planted forest (CPF). There were significant differences in CACI among the plantation areas. The highest monetary value was about US $ 881.92 of CO_2 sequestration in Shreepur PP whereas it was the lowest US $ 85.33 in Ramnagar CPF. Meanwhile, the estimated total monetary value of CO_2 sequestration was US $ 2525.00.

Key words : CO_2 sequestration, public plantation, community forest

INTRODUCTION

Managing carbon either by reducing deforestation and forest degradation or by enhancing the tree cover has significant value in REDD+ (UNFCCC, 2010) and it can add high value if plantations are managed by the landless poor communities. The ultimate goals of REDD+ are cut off pressure on the forest either by establishing the plantation, enhancing regeneration or reducing the deforestation and forest degradation and REDD+ offers to improve the livelihood of the poor communities (Campbell, 2009 and Hett *et al*., 2011). The payments for forest carbon sequestration are an emerging opportunity for small forest owners to earn additional income, and in turn to sustain both the economic and ecological values (Brooke, 2009). Public and private plantation have been playing a significant role in minimizing pressures on the natural forest from distant poor rural community in some Tarai districts. These plantations may be the candidate of forest carbon trade under the REDD+ mechanism.

Annually, there is decline in world's forest areas due to heavy pressure of increasing poor plant populations. The global net change in forest area during the period 2000–2010 was estimated to be 5.2 million ha annually but plantation was accounting for 130 million ha by area and 3 per cent of world's forest (Mini and Rao, 2011). Southeast Asia experienced the largest shrink in forest area since last ten years, with an annual net loss of more than 0.9 million hectares of forest. In Nepal, about 84,000 hectares of forest were deforested annually between 1991 and 2001. Out of this, the annual deforestation was nearly ten thousand hectares in Tarai, but there was positive change in forest cover i.e. about 0.25 per cent in Mahottari district between 1991 to 2001 (Anon., 2005) improving the forests through community based forest management. Still, people realize that there is increase in deforestation and forest degradation activities (Pokarel, 2011).

Carbon sequestration occurs when carbon is captured and securely stored, normally in vegetation, soil and rock. Atmospheric carbon is causing climate change which needs to be reduced through carbon sequestration. Climate change is already affecting precipitation and temperature patterns around the world, causing droughts, raising sea levels and increasing the strength and frequency of storms.

MATERIALS AND METHODS

Research site

The research sites were selected in Mahottari district of Nepal, which is situated in 26° 36' to 28° 10' N and 85° 41' to 85° 57' E. The annual temperature ranges between 20-45^{0}C and annual rainfall recorded between 1100-3500 mm. Three CPFs and three PPs were selected as study sites (Fig. 1) in Mahottari district. The community plantations *viz.* Sita (5.42 ha), Jogikuti (8.60 ha) and Ramnagar (4.92 ha) are planted in 2006, 2007 and 2008 respectively. Similarly, public plantations *viz.* Bisbitty (7.6 ha), Banuata (8.8 ha) and Shreepur (10.5 ha) were also planted in 2006, 2007 and 2008 respectively. The major planted species were pure *Eucalyptus camaldulensis* in all the sites and naturally regenerated species such as *Cynodon dactylon* and *Mimosa pudica* were observed.

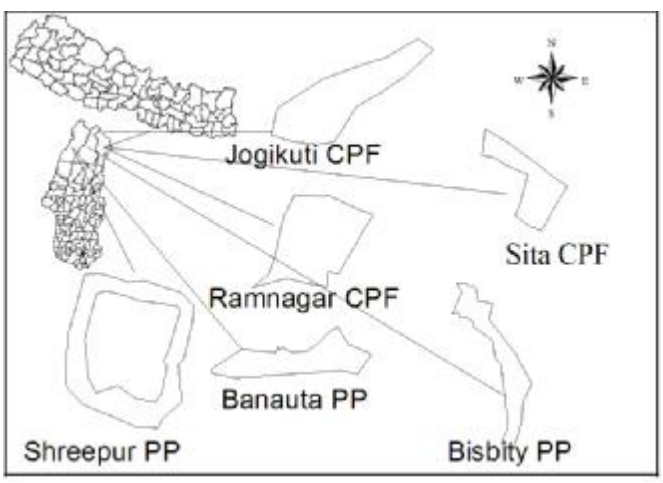

Fig. 1 : Map of Research Site

Data Analysis

The bio-physical data and document were associated with plantations and REDD+ were collected for the study.

Bio-physical data

The maps of these plantation areas were prepared using the coordinates taken by Geographical Positioning System (GPS) with the help of Arc GIS software. Simple random sampling was used maintaining 1per cent sampling intensity. Altogether 52 samples were taken from plantations site. Out of that, 11, 9 and 8 sample plots were fixed at Banauta, Shreepur and Bisbitty plantation sites respectively whereas 6, 7 and 11 sample plots were selected at Sita, Jogikuti and Ramnagar community planted forests respectively to collect the data. The centre point coordinate of sample plots were taken from the map and uploaded in the GPS and navigated the points to establish the nested plots in the field. The plantations were generally pole size. The plot size of 10 m x 10 m were laid out for pole and 1 m x 1 m for litter and grasses while soil samples were taken from the centre at 0-0.1 m, 0.1-0.3 m and 0.3-0.6 m depths. Height and diameter at breast height (DBH) of poles and sapling (DBH > 5cm) were measured but the samples of sapling (DBH < 5cm), grasses, litter and soil were taken to the lab for dry weight measurement. The samples were collected for three consecutive years following the same method as mentioned above in order to find the current annual carbon increment (CACI); started in 2011.

Ancillary data

In addition to plans of community planted forest and public plantation, policies documents of REDD+ were also collected. Small group discussion was conducted to know the practice of implementation of operational plan of these plantations. Mean while web search was also carried out to find out the current market price of carbon.

Analysis

The bio-physical data was analyzed by applying simple statistics i.e.the Statistical Package in Social Science (SPSS) software version 17. The biomass of plants having DBH > 5cm and DBH < 5cm was calculated using allometric equation of Chave *et al.* (2005) and Tamrakar (2000) respectively but Tamarakar (2000) provides only the fresh weight of the samples; and the collected samples were dried in the lab to get the dry weight. At the same time,

samples of litter and grasses were also dried. Moreover, the root biomass was calculated multiplying by conversion factor 0.125 of shoot biomass. Then, wood carbon was calculated by multiplying with 0.47 of dry biomass (Mac Dicken, 1997). On the other hand, soil bulk density and carbon content were calculated by using Walkey and Black (1958) and Chabbara *et al*. (2002) methods respectively.

The current annual carbon increment (CACI) was also calculated using following formula. Then, the value was changed into CO_2 multiplying conversion factor 44/12 in order to show the CO_2 removal from atmosphere.

Current Annual Carbon Increment (CACI)=Carbon stock of year (n) - Carbon stock of next year (n-1) derived by Lal (2007).Then, the CACI of plantations was compared using one way ANOVA. Similarly, the current annual removal of CO_2 was also estimated. Later the valuation of CO_2 sequestration was carried out by multiplying with the rate of US$ 5 CO_2/t (Molly *et al*., 2012).

RESULTS AND DISCUSSION

Current annual carbon increment variation in public plantation and community planted forests

The estimated current annual carbon increment (CACI) was found to be the highest 6.56 t ha^{-1} in third year in Shreepur public plantation whereas it recorded the lowest 1.02 tha^{-1} in Ramnagar community planted forest (Table 1). The users of Shreepur practised agro-forestry conducting weeding and cleaning operations simultaneously but user group of Ramnagar community planted forest have not carried out any types of silvicultural practices at all, so the estimated CACI was the highest in previous one and lowest in latter one. Indeed, no study was undertaken regarding the CACI in eucalyptus in Nepal but Amatya *et al*. (2002) observed that the yield table of Sagarnath plantation showed differences in carbon stocks of two consecutive years (year 7 and year 6) up to 4.4 t ha^{-1} which matched with the the present finding of average current annual increment of Banauta public plantation. Meanwhile, Tamrakar (2000) biomass table showed that the change of two consecutive years (year 7 and year 6) in carbon stock was 5.78 t ha^{-1} which was almost similar to the present research finding of Shreepur public plantation.

Comparison of C stock change in public and community planted forests

The homogeneity test was carried out for variances of average current annual carbon increment which showed no significant value with 0.48. As hypothesis was set whether there was difference in current annual carbon increment in different years of plantation. In this context, one way ANOVA showed that the P value was 0.00, so it can be decided that there was significant differences at 5% level of significance in current annual carbon increment in plantations of different sites. In addition, Tukey's HSD showed that there were significant differences in current annual carbon increment among the plantation areas. However, there was no significant difference in three different conditions: between Shreepur PP and Banauta PP, Bisbity PP and Sita CPF, Ramnagar CPF and Jogikoti CFP (Table 2 and 3).

Table 1 : Current Annual Carbon Increment (t ha^{-1}) in plantations

Plantation types	Year 1	Year 2	Year 3	CACI (C of yr2- yr1)	CACI (C of yr3- yr2)	Average annual increase
Shreepur PP	61.19	65.44	72.00	4.25	6.56	5.41
Banauta PP	15.29	19.00	25.00	3.71	6.00	4.86
Bisbitty PP	13.6	17.47	21.04	3.87	3.57	3.72
Sita CPF	77.56	81.56	83.56	2.00	4.00	3.00
Ramnagar CPF	24.8	25.00	27.33	1.02	2.33	1.68
Jogikuti CPF	15.44	16.67	18.9	1.23	2.23	1.73

The current annual increment of carbon stock depends on the site, quality, species, nature of growth, management practices and age of the plants (Prakash, 2001 and Lal, 2007). Therefore, such differences were observed in these public plantations and community planted forests.

Table 2 : One way ANOVA

Variance	Sum of Squares	df	Mean Square	F	P-value (Sig.)
Between Groups	120.343	5	24.07	101.97	0.00
Within Groups	11.566	49	.236		
Total	131.909	54			

Table 3 : Multiple Comparisons using Tukey's HSD

Plantation site	Plantation sites (sample sites)	Mean Difference (I-J)	Std. Error	P-value (Sig.)
Shreepur PP	Banauta PP	0.55	0.21	0.10
	Bisbitty PP	1.69(*)	0.22	0
	Sita CPF	2.41 (*)	0.25	0
	Ramnagar CPF	3.74(*)	0.23	0
	Jogikuti CPF	3.69(*)	0.21	0
Banauta PP	Shreepur PP	-0.55	0.21	0.10
	Bisbitty PP	1.16(*)	0.22	0
	Sita CPF	1.86(*)	0.25	0
	Ramnagar CPF	3.18(*)	0.23	0
	Jogikuti CPF	3.13(*)	0.21	0
Bisbitty PP	Shreepur PP	-1.69 (*)	0.22	0
	Banauta PP	-1.14(*)	0.22	0
	Sita CPF	0.73	0.26	0.07
	Ramnagar CPF	2.05(*)	0.24	0
	Jogikuti CPF	1.99(*)	0.22	0
Sita CPF	Shreepur PP	-2.41(*)	0.25	0
	Banauta PP	-1.86(*)	0.25	0
	Bisbitty PP	-0.73	0.26	0.07
	Ramnagar CPF	1.32(*)	0.27	0
	Jogikuti CPF	1.27(*)	0.25	0
Ramnagar CPF	Shreepur PP	-3.74(*)	0.23	0
	Banauta PP	-3.18(*)	0.23	0
	Bisbitty PP	-2.05(*)	0.24	0
	Sita CPF	-1.32(*)	0.27	0
	Jogikuti CPF	-0.05	0.23	1
Jogikuti CPF	Shreepur PP	-3.68(*)	0.21	0
	Banauta PP	-3.13(*)	0.21	0
	Bisbitty PP	-1.99 (*)	0.22	0
	Sita CPF	-1.27 (*)	0.25	0
	Ramnagar CPF	0.05	0.23	1

* The mean difference is significant at the .05 level.

Valuation of CO_2 sequestration in public plantation and community planted forests

The estimated value was varied according to the changes in CO_2 sequestration. The plantation area of Shreepur PP was the largest among others and the CO_2 sequestration was also highest in this public plantation. The highest monetary value was estimated around US $ 881.92 of CO_2 sequestration in Shreepur public plantation followed by Banauta PP (US $ 658.66) whereas it was the lowest US $ 85.33 in Ramnagar community planted forest. Meanwhile, the estimated total monetary value of CO_2 sequestration from all plantation areas was US $ 2525.00. In contrary, the CO_2 sequestration of Ramanagar was the lowest and its area was the smallest among others. The lower CO_2 sequestration (tha^{-1}), the lower is the monetary value (Tewai *et al*., 2007).

Table 4 : Value of CO_2 Sequestration in plantations

Plantation types	Annual CO_2 sequestr-ation (tha^{-1})	Total CO_2 sequest-ration (t)	Monetary value US $
Shreepur PP	19.82	176.38	881.92
Banauta PP	17.80	131.73	658.66
Bisbitty PP	13.64	85.93	429.66
Sita CPF	11.00	47.52	237.60
Ramnagar CPF	4.60	17.07	85.33
Jogikuti CPF	6.34	46.22	231.12
Total			2525.00

CONCLUSION

The estimated current annual carbon increment (CACI) was recorded to be the highest in Shreepur public plantation whereas it was the lowest in Ramnagar community planted forest. This difference was mainly due to weeding and following package of silviculture practice at Shreepur but not in Ramnagar. Therefore, recommendation must focus on adopting right agronomical practices that proved to give significantly higher productive community planted forest. But it is basically lacking. This would have otherwise ensure poverty alleviation, more employment and finally enable reach REDD+ target.

The estimated current annual carbon increment (CACI) and CO_2 sequestration varied according to

the plantation sites along with the monetary value of CO_2 sequestration. The monetary value of CO_2 sequestration was estimated to be the highest in Shreepur public plantation and the lowest in Ramnagar community planted forest.

As the international policies have been focused on stock change method to determine the value of forest carbon, such studies should be explicitly carried out in other sites as well. All possible silviculture recommendations should be practised to raise the forestry and then compare between sites for relative higher or lower productive strategies.

Bundling of small scale plantations with other natural forests could be candidate for carbon trade under the REDD+ mechanism. But its exotic and normal abundance of species instead of monoculture of eucalyptus which has proved to be deleterious in many ways should be ensured.

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BIOLOGICAL POWDERED ACTIVATED CARBON MEMBRANE BIOREACTOR (BPAC-MBR) FOR TREATMENT OF INDUSTRIAL WASTEWATER

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ABSTRACT

Activated carbon is a commonly used adsorbent for colour and odour removal in tertiary treatment of wastewater. This study examines the effect of powdered activated carbon (PAC) addition on reactor performance during secondary (biological) treatment of high strength industrial wastewater. The effluent used was anaerobically digested spent wash from sugarcane molasses distillery. This wastewater has a high organic load (35-40 g chemical oxygen demand (COD)l^{-1}), dark brown colour and high solids content (80 mg l^{-1}). The PAC acts both as a support for bacterial immobilization as well as a media for adsorption. Different commercial activated carbons were screened on the basis of their ability to reduce COD and colour. Depending upon the PAC properties, up to 70% COD and 80% colour removal were obtained at a dosage of 15g PAC l^{-1}. The ratio of colour removal to COD removal varied with the PAC used. The bioreactors were fabricated locally. Ceramic membranes prepared from biomass ash were submerged in the bioreactor and used for sludge separation. Sludge from a municipal wastewater treatment plant was inoculated and was gradually acclimatized to the distillery wastewater under aerobic conditions. The reactor contents and filtrate were monitored for mixed liquor suspended solids (MLSS), mixed liquor volatile suspended solids (MLVSS), COD, extracellular polymeric substances (EPS), protein and carbohydrate content in the EPS fractions. Sludge settling was determined by measuring the capillary suction time (CST). PAC addition stabilizes the reactor after shock-load and improves sludge dewaterability.

Key words : Distillery wastewater, membrane bioreactor, activated carbon

INTRODUCTION

Alcohol production from sugarcane molasses generates large volume of wastewater in the distillation step 14 kl wastewater/kl alcohol, (Satyawali and Balakrishnan, 2009). This wastewater is characterized by extremely high chemical oxygen demand (COD) (80–100g l^{-1}), high biochemical oxygen demand (BOD) (40–50 g l^{-1}), is acidic and has dark brown colour (Pant and Adholeya, 2007; Satyawali and Balakrishnan, 2009). The colorants include melanoidins, caramel, anthocyanins, tannins and different xenobiotic compounds (Pandey *et al*., 2003), which makes this a difficult effluent stream to treat. Melanoidins are dark brown to black coloured compounds produced by non-enzymatic browning known as Maillard reaction. Products from Maillard reaction are reported to have antioxidant, antiallergenic, antimicrobial and cytotoxic properties and can act as reducing agents, metal chelators and radical scavengers (Plavsic *et al*., 2006). Because of their antioxidant properties, melanoidins are toxic to microorganisms and cannot be degraded easily by the biological route (Kumar *et al*., 1997).

As a first step, almost all Indian distilleries employ anaerobic treatment. This is done in high rate digesters like upflow anaerobic sludge blanket (UASB) reactors. The treated wastewater still has high COD (30 to 40 g l^{-1}) and suspended solids (80 mg l^{-1}); also the colour intensifies upon anaerobic treatment. Thus it cannot be discharged and further treatment is required for reduction of COD and colour.

The ability of PACs to adsorb pollutants is well established and several works have been reported on PAC assisted membrane filtration and oxidation systems. PAC addition combined with oxidation has been reported for treatment of synthetic textile wastewater (Oguz and Keskinler, 2008). Here, ozonation and 0.5-1 g l^{-1} PAC addition showed 96% COD removal against 51% COD removal with ozonation alone.

Over the last two decades, membrane bioreactors (MBR) have been extensively studied for treatment of both municipal and industrial wastewater. MBR combines suspended growth in a bioreactor and filtration through a porous membrane for biomass retention. To further improve the operation, MBRs supplemented with activated carbon have been reported. Most studies are with powdered activated carbon (PAC) though some researchers have used granular activated carbon (GAC) as well (Nguyen *et al*., 2011). The activated carbon provides a support for microorganisms to attach and grow. Organics adsorbed on the PAC/GAC can thus be degraded by the microorganisms. Other supports such as sponge cubes may also be used for attached growth-MBRs (Khan *et al*., 2011).

This study examines two aspects viz (a) PAC best suited for adsorbing organic and colour components in distillery wastewater (b) the effect of PAC addition on a reactor that has experienced shock-loading.

MATERIALS AND METHODS

Anaerobically treated molasses distillery wastewater was collected from Simbhaoli Sugars Ltd., Ghaziabad District, UP. The COD values for the two lots collected for this work was around 42±2 g l^{-1}. Sludge was obtained from the municipal wastewater treatment plant at Okhla, Delhi. The activated carbons studied are listed in Table-1. Except for the unburnt carbon sample, all carbons were procured commercially and used as-received.

Table 1 : Different activated carbons screened for COD and color removal.

Activated carbon description	Code
Powdered activated carbon(Supra spl)	UNC
Powdered activated carbon(Merck)	CM
Activated charcoal decolorizing (Sigma Aldrich)	CDE
Activated charcoal Darco powder 100 mesh (Sigma Aldrich)	CDARCO
Steam activated coconut shell carbon (Active char product)	CAC
Activated carbon (Eco fresh)	CECO
Innova powdered activated carbon (Innova)	CI
Unburnt carbon (prepared in house, by separating from bagasse ash)	UnC

Screening of activated carbons

The distillery wastewater was diluted in a ratio of 1:4 with distilled water. 100 ml of the diluted wastewater was mixed with a known amount of a given PAC (0.5, 1, 1.5 g) in a 250 ml conical flask. An additional flask with 100 ml diluted wastewater but no PAC addition served as the blank (control). The flasks were kept in a shaker at 160 rpm and 25°C for 30 min. The mixture was then centrifuged at 8000 rpm for 20 min to separate the PAC particles. The supernatant was tested for color and COD. COD was determined as per Standard Methods. Color was measured spectrophotometrically at 475 nm using spectrophotometer (Shimadzu, UV-1700 Pharma spec). The experiments were replicated twice.

MBR operation

The MBR was fabricated locally using transparent polyacrylic material (Fig. 1). The reactor working volume was 8 l. Compressed air at 4.5-5 lpm was supplied via a diffuser (Southern Cogen Pvt Ltd., Chennai) located at the bottom of the reactor. The compressed air at 8 kg/cm^2 was obtained using ELGI Dr. Vayu air compressor, India.

Sludge was acclimatized using synthetic wastewater (prepared as per the composition given by Shim *et al*., 2002). The synthetic wastewater was gradually replaced over a period of 30 days by distillery wastewater. The reactor was operated in a fed-batch mode during this period. Once the synthetic wastewater was completely replaced, the reactor was operated in continuous mode. Anaerobically treated distillery wastewater was used as-received, without any dilution, throughout the experiment. A ceramic membrane filter (developed in-house) was immersed in the reactor and the treated wastewater was sucked through the filter using a peristaltic pump. The hydraulic retention time (HRT) was 7 days. The aeration rate was 4.5-5 lpm and pH of the reactor contents was maintained around 8.5. The reactor experienced a shock load due to excess solids and high COD in the incoming wastewater. The different phases of reactor operation post shock-load are summarized in Table-2.

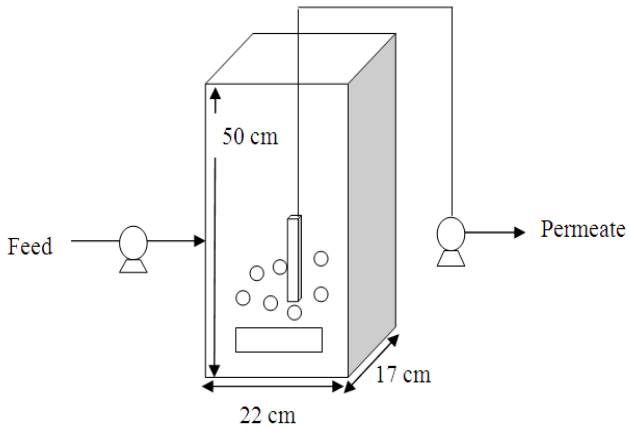

Fig.1 : Schematic diagram of reactor operation in fed batch mode (membrane : ▯; peristaltic pump ⚲; diffuser ▭; air bubbles ○)

Table 2 : Different phases of reactor operation.

Phase	Operation duration (d)	Operation mode	Remarks
I	30	continuous	Feed had high MLSS (80.63 mgl^{-1}) and high COD (57,000 mg/L); feed was added as received and no pretreatment (sieving) was done; permeate withdrawn through membrane module
II	35	fed batch	Reactor was emptied, acclimatized sludge was sieved (2mm sieve followed by 0.5mm sieve) and membrane module was removed· Reactor operation was initiated with acclimatized sludge using fresh distillery wastewater; operation volume 8l; PAC supplementation on days 2, 4 & 5 (16g, 2 g and 2 g respectively) of Phase II· Reactor operation in fed batch mode - fresh feed was added to make-up for the volume lost by evaporation and sample collection for analysis.
III	40		Feed was stopped but aeration was continued; very limited samples were withdrawn in this phase
IV	30	fed batch	Fed-batch operation was initiated with fresh lot of distillery wastewater (MLSS 0.8 mg l^{-1}, COD 41,184 mg l^{-1}).The COD and MLSS of feed were around 41,000 mg $l^{-1}$and 80 mg l^{-1}respectively.

Analysis

Mixed liquor suspended solids (MLSS), mixed liquor volatile suspended solids (MLVSS), chemical oxygen demand (COD) of the feed, permeate and reactor contents (as applicable) were analysed according to Standard Methods (APHA, 1995). Care was taken to ensure uniform mixing of the reactor contents before withdrawing the sample for analysis. Extracellular polymeric substances (EPS) of the reactor contents was analysed by the method given by Chang and Lee (1998). Protein content and total carbohydrate in the EPS fractions were measured respectively by Lowry method (Lowry *et al.*, 1951) and phenol-sulfuric acid method (Dubios, 1956). The sludge dewaterability of the diluted reactor sample was estimated by using capillary suction timer (Type 304 M, Triton Electronics Ltd., UK).

RESULTS AND DISCUSSION

Screening of different activated carbons

Fig.2 (a) and 2(b) show the colour and COD removal with different carbons studied in this work. Among these, CDARCO shows the best performance with COD removal of 70% and color removal of 80% at a dose of 15g l^{-1}. Some of the samples like CECO and UnC show almost no color removal. In all cases, the removal was higher at higher dosage. The ratio of colour to COD removal varies with the PAC type as in Fig. 2(c). The ratio was ~1 for CDARCO (indicating colour and COD is removed to the same extent).

CM was used as the additive in the biological reactor. This sample shows low color removal (up to 18%) and moderate COD removal (up to 36%) at the highest PAC dosage of 15g l^{-1} used in this work. This carbon was chosen since it is well characterized

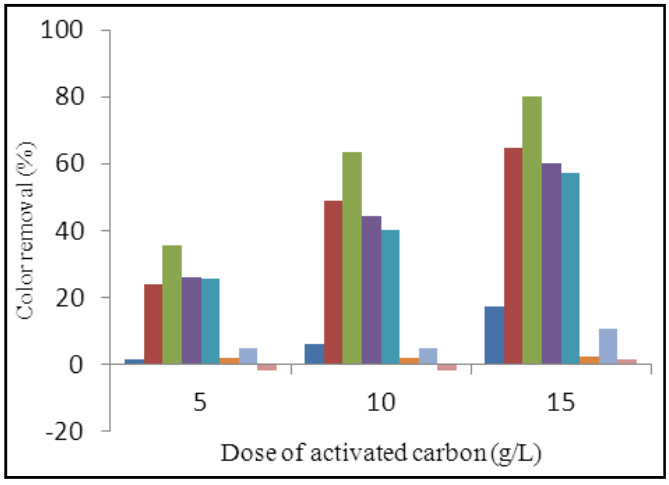

Fig. 2 (a) : Color removal

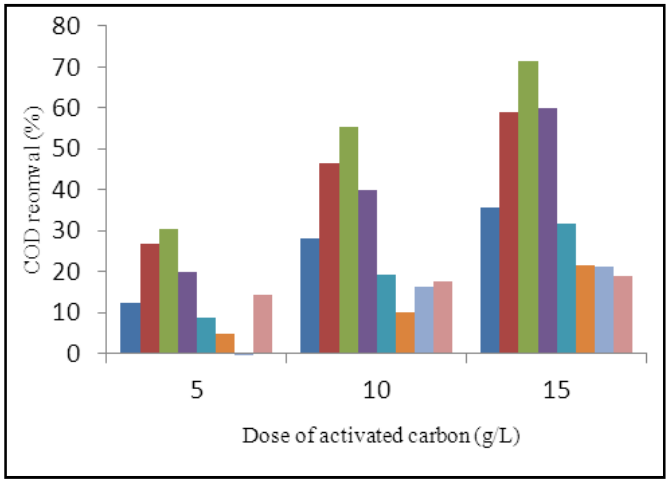

Fig. 2 (b) : COD removal

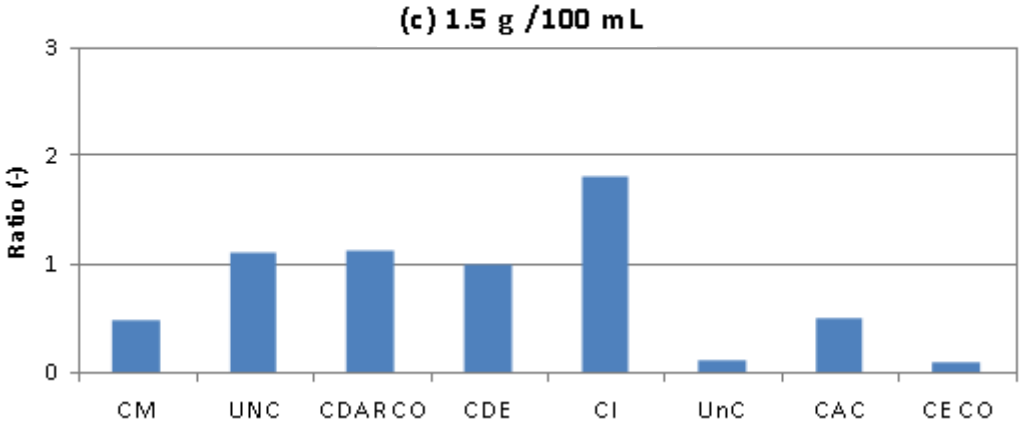

Fig. 2 (c) : Ratio (colour removal / COD removal) at 15 g PAC l^{-1}
(■: CM; ■: UNC; ■:CDARCO; ■:CDE; ■:CI; ■:UnC; ■:CAC; ■:CECO)

Biological activity in the reactor after PAC addition

After acclimatization and nearly 2 months of continuous operation at a HRT of 7 days, 40-50% COD removal and 20-25% color reduction was observed (results not shown). This was prior to the shock load. Fig. 3(a) shows the biomass growth in the reactor after the shock load. The corresponding COD/VSS ratio (gCOD consumed per gVSS in the reactor) is shown in Fig.3(b). The MLSS in phase II is marginally lower than in phase I and the values were scattered. The VSS profile showed a similar trend. Even though precaution was taken to ensure the reactor contents were uniformly mixed before withdrawing the sample for analysis. The MLSS and VSS stabilized around 20 g l^{-1} and10 g l^{-1} in phase IV respectively. The added PAC would have also contributed to the VSS content. The VSS/MLSS ratio was marginally higher in phase IV compared to phase I (no PAC addition), but the ratio is low (< 0.5) indicating poor biomass growth. Thus, it appears that PAC addition eventually stabilizes the MLSS and VSS in the reactor, but does not improve the biomass growth. This may also be related to the PAC properties. Even at 5g l^{-1}dosage (Fig. 1), the PAC used in the reactor (CM) shows low color and COD removal. The dosage used in the reactor was ~2g l^{-1}; thus the PAC is not expected to contribute substantially towards COD and color removal by adsorption.

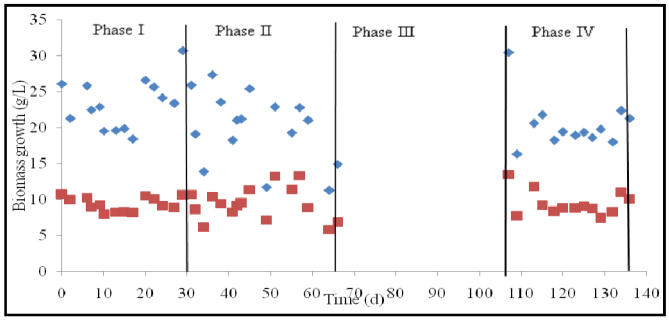

Fig. 3 (a) : Biomass growth in the reactor with time (f & : MLSS; % : VSS)

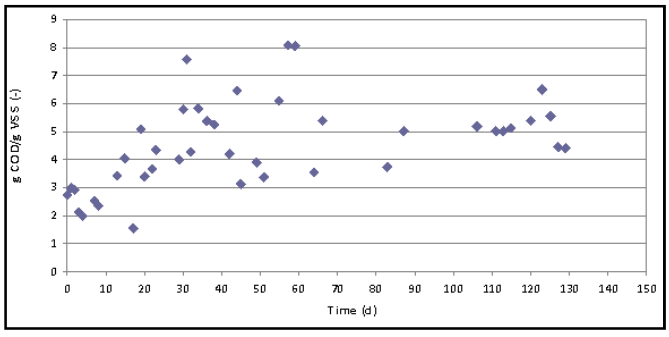

Fig. 3 (b) : Shows an increase in the COD/VSS ratio upon PAC addition. This indicates that there is an improvement in the sludge activity (Vadlani *et al,* 2008).

EPS content in the sludge

The variation in EPS content with time shows that the soluble EPS content is 3 to 6 folds higher than the bound EPS content (Fig. 4). There is a small reduction in the soluble EPS content upon PAC addition, possibly due to adsorption on the PAC. The bound EPS shows a marginal increase upon PAC addition (~1.5 fold). This observation is in contrast to literature reports (e.g. Kim *et al*., 1998; Lee *et al.*, 2010) showing decrease in bound EPS upon PAC addition. However, in an earlier study with distillery wastewater, total EPS content appeared to be independent of PAC addition but a variation in the composition (protein/carbohydrate ratio) was observed (Satyawali and Balakrishnan, 2009). Overall, there is a marginal reduction in total EPS upon PAC addition.

The protein content in soluble and bound EPS fractions is considerably higher than the carbohydrate content (Fig. 5). Overall, both the protein and carbohydrate content is greater in the soluble fraction. After PAC addition, though there is

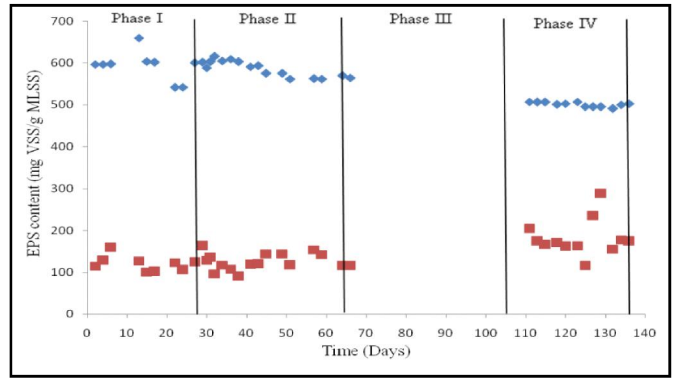

Fig. 4 : Variation in EPS content with time (f & : soluble EPS; % : bound EPS)

an initial variation in the P/C ratio (Phase II), it becomes almost identical for both bound and soluble fractions (Phase IV). High protein content signifies that there is a high amount of secretion and cell lysis by microbial cells. The increase in cell lysis can occur due to the decrease in microbial growth rate (Liao *et al*., 2000).

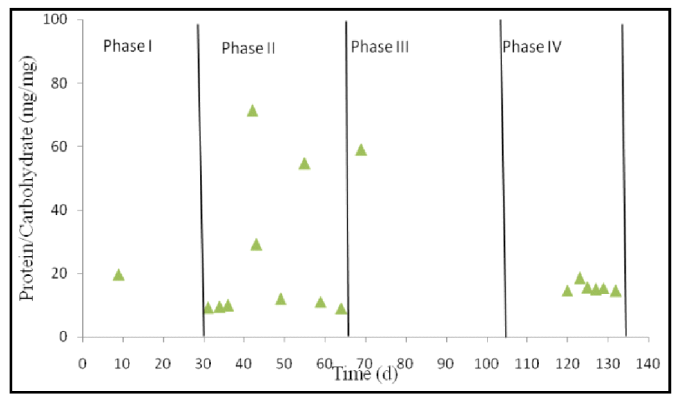

Fig. 5 : Variation in ratio of protein content to carbohydrate content with time

Sludge dewaterability after PAC addition

Fig. 6 shows the variation in CST with respect to time. The CST clearly decreases upon PAC addition from 2000 s to 10s over a period of 140 days. This indicates an improvement in sludge filterability.

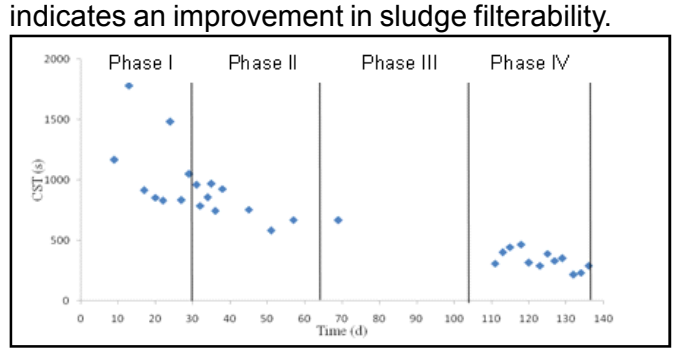

Fig. 6 : Variation in CST with time

CONCLUSION

CDARCO is best among the tested carbons for both COD and colour removal from distillery wastewater. However, even with this PAC, high dosage would be required for high COD and colour removal. Even if the COD and colour removal is poor with a specific PAC, its addition can stabilize the reactor upon shock-loading and improve sludge filterability.

ACKNOWLEDGEMENT

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NON RANDOM DISTRIBUTION AND FREQUENCY OF SIMPLE SEQUENCE REPEATS IN NON CODING AND PROTEIN CODING GENOMIC REGION OF INDIAN MAJOR CARP, *(Labeo rohita* H.*)*

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ABSTRACT

Simple sequence repeats or microsatellites have been found abundantly in genomes of many organisms. However, the abundance and frequency of distribution in Indian major carps has not been studied. Availability of sequences in the public database allows insilco analysis allows us to better understand and characterize microsatellites. The numbers and frequency of different types of repeat motifs varies between non-coding and coding region of *Labeo rohita* genome. Dinucleotide repeats are the most abundant SSRs in non-coding region and among dinucleotide motifs AC/GT repeat motifs are most common. In contrast in the protein coding region tetranucleotide repeats are the most common SSR motif. The frequency of occurrence of SSR motifs in non-coding and protein coding region of rohu genome was found to be one SSR/157.4 bp and one SSR/5kb respectively.

Key words : Microsatellite, coding region, non-coding sequences, Indian major carp

INTRODUCTION

Microsatellites also known as simple sequence repeats are tandemly repeated stretches of DNA consisting of 1-6 base pair (bp) long units, occur frequently and are ubiquitously interspersed in many genomes (Gur-Arie *et al.,* 2000; Toth *et al.,* 2000), even in the smallest bacterial genome (Field and Wills, 1998 and Hancock, 1995).The length of the repeat motif postulated to vary through the effect of replication slippage and unequal recombination (Richards and Sutherland, 1992; Schlottere and Tautz, 1992 and Khajavi *et al.,* 2001). Mutation of microsatellite loci occur through insertion or deletion of few repeat motifs and rate mutation normally increases with increase in length of repeat tract (Wierdl *et al.,* 1997). Due to certain attributes like high polymorphism, amenable to PCR, codominant in nature and densely interspersed in eukaryotic genomic microsatellites are widely utilized for individual identification, genetic diversity studiers and construction of linkage maps and quantitative trait loci analysis. Occurrence of microsatellites vary between various genomic regions; they preferentially associated with non repetitive sequences (Morgante *et al.,* 2002), and some patterns of repeat, predominant in certain genomic regions (Hancock 1995; Toth *et al.,* 2000; Borstnik and Pumpernik 2002 and Subbaya *et al.,* 2003). The differential distribution of microsatellite repeats imitates the propensity of mutational processes to generate certain repeat patterns under selective pressure (Ricke *et al.,* 1995). Similar to non coding regions SSR motifs can also occur in coding region of DNA, leading to appearance of repetitive patterns in the protein sequences. Tandem repeats are common in many proteins (Katti *et al.* 2000) and the mechanism of generation of these tandem repeats leads to rapid evolution proteins (Green and Wang 1994; Huntley and Golding 2000). Experimentally hybridization technique is used to estimate the distribution of microsatellites in different genomes (Tautz and Renz 1984; Panaud *et al.,* 1995). However the accuracy of this technique could not be relied using oligonucleotides like (AT)n and (GC)n that can self-complement. With the advent of sequencing

technology the nucleotide databases are getting enriched. Numerous reports on abundance of simple sequence repeats in different genomes are available in the literature (Hancock, 1995; Jurka and Pethiyagoda, 1995; Richard and Dujon, 1996; Bachtrog *et al*., 1999 and Kruglyak *et al.,* 2000). However no such data is available in Indian major carp, *Labeo rohita H.* (rohu).

MATERIALS AND METHODS

DNA sequences

All the genomic and coding sequences of rohu were downloaded in FASTA format from May 2013. A total of 566 genomic sequences and 223 coding DNA sequences were retrieved in FASTA format and compared with the BLAST packages (BLASTn) to avoid sequence redundancy. The no. of sequences and their lengths variation are shown in Table 1.

Table 1 : Number of sequences downloaded and their size range

Sl. No.	Sequences	No of Sequences	Maximum Size	Minimum Size
1	Non-coding	566	84	567
2	Coding	223	102	6420

Microsatellite screening

Unbiased estimates of microsatellite frequency from genomic DNA entries presented several caveats: (1) genomic DNA is underrepresented in databases, (2) most of the published microsatellites were isolated from enriched libraries and consequently their frequencies may be overestimated, (3) most publications of partial genomic libraries only report sequences containing polymorphic microsatellites that are useful as genetic markers. Similarly estimates of microsatellite frequency from coding DNA sequence is also poised some limitations (1) coding DNA sequence is over represented in database (2) most of the published sequences are resulted from studies pertaining to gene characterization or to analyze expression level of that particular gene, therefore microsatellite frequency may be underestimated. All the sequences were scanned for various SSRs using web based program websat (Martins *et al.,* 2009) with the criteria 6 repeats for dinucleotides, 4 for tri and tetra nucleotides and 3 for penta and hexa nucleotides.

RESULTS AND DISCUSSION

The abundance of microsatellite motifs in the genome of rohu was roughly estimated from sequences retrieved from NCBI database through the screening of 566 genomic sequences and 223 coding DNA sequences. In the non coding region microsatellites were identified to examine the frequency and pattern of distribution in the genomic region of rohu. A total of 1176 SSRs were identified in the 566 genomic sequences of about 185.15kb size data for rohu in the present investigation (Table 2). As expected dinucleotide repeats were found to be most abundant among the microsatellites in the non coding region of rohu genome followed by tri, tetra, hexa and penta nucleotide repeats (Table 2). Dinucleotide repeats alone contributed to about 67.32% (Fig. 1). Among the dinucleotide repeat motifs (GT/AC)n repeats were found to be the most prevalent SSR motifs followed by (GT)n and (AT)n respectively (Fig. 1). Among the trinucleotide repeats (CTC)n were found to be most abundant SSR motifs followed by (ATC)n, (ATG)n, (GAA), (ACA)n, (CAC)n, (TTA)n (TGG)n and (TGC)n repeats motifs (Fig. 2). The global abundance of microsatellite repeats in the non coding genomic sequences of rohu was found to be one SSR/157.4bp. In the similar fashion SSR were identified in the coding sequences to scan the pattern and distribution in rohu genome. A total of 27 SSR were observed in 223 CDS of about 135.1kb sequence data (Table 2). In the coding region of rohu genome tetranucleotide repeats were found to be the most abundant repeat motifs followed by penta, tri, di and hexa nucleotides (Table 2). The global abundance of microsatellite repeats in the coding DNA sequences of rohu was found to be one SSR/ 5 kb. With the advent of sequencing technology in

Table 2 : Numbers of different types of repeat motifs in non-coding and coding DNA sequences of *Labeo rohita*

Sl. No.	Non-coding sequences		Coding sequences	
	Types of repeat motif	Numbers	Types of repeat motif	Numbers
1	Dinucleotides	779	Dinucleotides	4
2	Trinucleotides	200	Trinucleotides	4
3	Tetranucleotides	161	Tetranucleotides	11
4	Pentanucleotides	3	Pentanucleotides	6
5	Hexanucleotides	33	Hexanucleotides	2
	Total	1176	Total	27

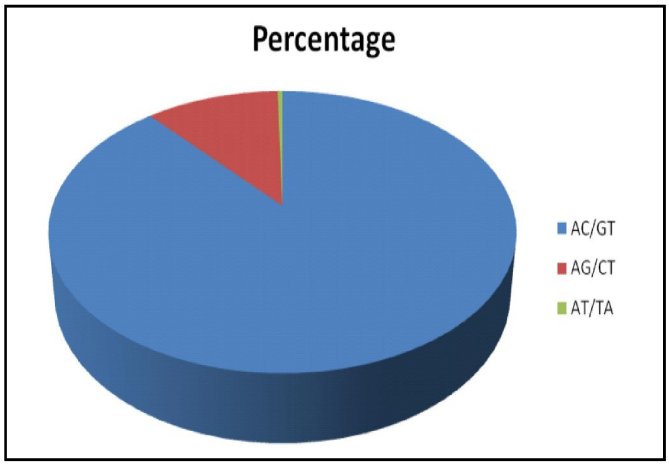

Fig. 1 : Percentage of different type of dinucleotides in non-coding genomic region of *Labeo rohita* genome

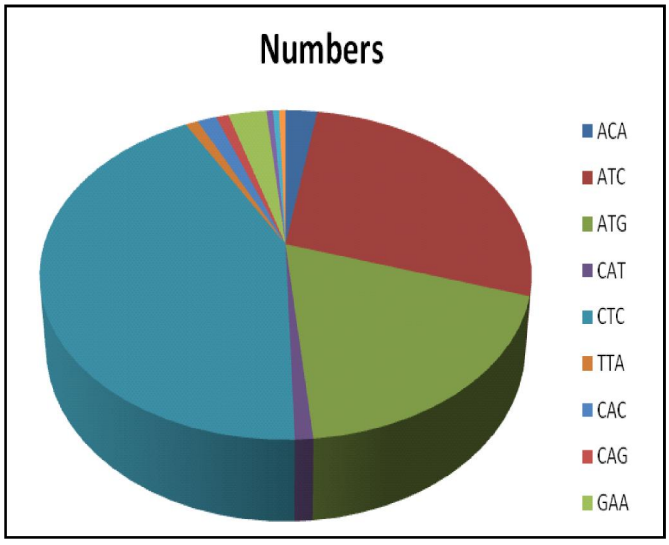

Fig. 2 : Number of different types of trinucleotides in non coding genomic region of *Labeo rohita* genome

recent years, research endeavors have generated a number of genomic and transcribed ESTs from many species, and researchers are now able to access the important information contained within these sequences. In the present investigation we examined the distribution and frequency of perfect microsatellites composed of motifs 2-6 bp long in rohu genome. The result of the present investigation showed that SSR motifs are not randomly distributed in rohu coding and non coding genomic regions. Nonetheless, analysis of available sequence datasets resulted in several worth mentioning findings. It is very informative to compare the repeat occurrence in non-coding and coding region of the rohu genome. At the same time restraints shaping protein coding DNA sequences obviously differs from that affects non coding DNA sequences. SSR motifs are not regularly distributed within the genome because of difference in their frequencies within coding and non-coding sequences (Arcot *et al* .,1995 and Wilder and Hollocher, 2001) and possible functional roles of different repeats (Valle 1993). In the present investigation the frequency of occurrence of microsatellites is higher in non-coding DNA region (SSR/157.4 bp) than the coding region (one SSR/ 5kbp). High mutation rate was observed in the microsatellites repeat motifs. Attributable to this reason it is to be expected that coding DNA sequence have low microsatellite density because if they do not these regions would be significantly altered, possible leading to loss of functionality. The result was in agreement with the findings reported by Toth *et al.* (2000), who compared the occurrence of microsatellites in both coding and non-coding regions of different species. SSRs have been shown to be in excess in non coding region of eukaryotes (Metzgar *et al.,* 2000). Among the microsatellites in the non coding region dinucleotides outnumbered other repeat types. In the non coding genomic region of rohu (AC/GT)n is the most common dinucleotide repeat motif. Similar results were reported in

vertebrate and non vertebrate species (Toth *et al.*, 2000). Cruz *et al.* (2005) reported that (AC)n are the most frequently occurred class of dinucleotide repeats in bivalves. In contrast (AT)n repeat motifs are least occurred repeat motifs in rohu. Dinucleotide repeat motif (AT)n are reported to be the second most abundant microsatellites in several vertebrae species (Toth *et al.*, 2000; Chistiakov *et al.*, 2005 and Cruz *et al.*, 2005). The contrasting result obtained in the present study may be due to the types of probes utilized to construct the microsatellite enriched partial genomic library in rohu. In contrast to the published reports trinucleotides are the second most abundant microsatellites repeat motifs and (CTC)n motifs are the most common triplets. Next to dinucleotide repeats tetranucleotides are found to be the most prevalent in most of eukaryotic genome studied (Tooth *et al.,* 2000; Chistiakov *et al.,* 2005 and Cruz *et al.,* 2005) and among the trinucleotide repeat motif (G+C) repeat motifs are found to be the most frequently occurred triplet repeat motif (Tooth *et al.*, 2000 and Chistiakov *et al.,* 2005). In the present investigation hexanucleotide SSRs outnumbered the pentanucleotides. In general, in the non coding region higher density of pentanucleotides are observed (Tooth *et al.,*2000). In contrast to other types of repeat motifs, triplets followed by hexnucleotides are found in high frequency in coding genomic region (Toth *et al.,* 2000 and Morgante *et al.*, 2002). However, in the present investigation tetranucleotide repeat motifs are the most common SSRs in coding region followed by pentanucleotides. These differed results may due to the amount of sequence data available for analysis. Rohu genome is estimated to be around 1950Mb (Patel *et al.,* 2011). However till date for a fraction of rohu genome, nucleotide sequence data are available in the database. Further studies with lager dataset are warranted before taking any conclusive discussion regarding the frequency and distribution of microsatellites in coding and non coding region of rohu genome.

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AQUACULTURE IN MULTIPLE USE WATER BODIES : INSTITUTIONAL PERSPECTIVES

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ABSTRACT

For centuries water resources are being created for various purposes like irrigation, domestic use, flood control and religious uses. A diverse range of water bodies are in use for multiple purposes. Aquaculture use has emerged as important one in the recent time but a very limited information is available on the nature of such use. But, the achievements in terms of production and productivity have been quite low for overwhelming technological and institutional constraints. The paper makes an attempt to go deeper into the issues and explores institutional framework involved in the aquaculture management. A logistic model is developed to determine the nature of use of the multiple use water bodies.

Keywords : Multiple-use, water resources, aquaculture, community-based management.

INTRODUCTION

The aquaculture in the multiple use water bodies (MAR) is an emerging trend. The water resources like village ponds, small irrigation structure, farm ponds, watershed ponds *etc.* are increasingly being used for the aquaculture purposes due to a significantly higher level of income and profit generation with limited investment in it. A survey of aquaculture in multiple use ponds indicates at the dire state of neglect and lower level of aquaculture development (Radhesyam *et al.*, 2011). The low level of technology application is primarily due to lack of appropriate institutional arrangements. Providing appropriate institutions is an important step towards exploring potentiality in aquaculture that would definitely enhance the productivity paving greater societal benefits.

In the state of Odisha, out of 1.2 lakhs ha of pond and tank only 0.8 lakh (60%) ha are being used for the aquaculture purposes. Among them, about 0.48 lakh ha are used for semi-intensive system where as 0.32 lakh ha are under extensive system. The average fish productivity from extensive and semi-intensive culture are 1.7 and 2.6 tonnes/ ha/ year, respectively in 2011. With the inclusion of the MAR in the state aquaculture resources, the net water areas of aquaculture can be increased to 188 thousand ha out of which MAR is about 76.3 per cent. These vast resources provide huge opportunity for the aquaculture development leading to production of quality protein as well as strengthening food and nutrition security of vast rural mass. But, the institutional constraints will act as most important impediments in the aquaculture development in such water bodies.

Looking at the importance of these resources from the aquaculture as well as development perspective, the present study is undertaken to assess the multiple use water resources in an institutional perspective. The field work was conducted during 2010-12 in coastal and interior parts of the state. The paper has the specific objectives of characterization of the MAR, delineation of institutional framework and estimations of the determinants of the multiple use nature of water resources through statistical modeling. This study will provide a new insight into the socio-economic environment of the aquaculture in MARs.

MATERIALS AND METHODS

The planning commission has divided the country into 15 agro-climatic zones out of which the state of Odisha is located in the two zones i.e East coast plain and hills (EG) and eastern plateau and hills (EH G). In the paper EG and EHG are presented as coastal and interior regions. The survey was

conducted among these water bodies in two regions of Odisha i.e Coastal (Puri and Khorda district) and Interior (Nuapada and Bargarh districts). The study is based on the three levels of data collection i.e village level, resource level and household level during 2010-2012. A total 83 water bodies(WBs) from 62 villages were sampled and about 5-6 household depending on the resources were also sampled. For development of statistical model 62 villages with one resource from the village and one dependent household from each resource were selected randomly for the purpose.

It is being observed that over a period of time most of the single use water resources are being converted into multiple uses. Even though most of the water resources are created for the single use like domestic, irrigation etc., in reality many of them are being used for multiple purposes. Single use water bodies are generally meant for one purpose like domestic use, aquaculture, irrigation etc., where as the multiple use WBs are used for more than one use. The nature of use as dichotomous variables (single or multiple use) are fitted into regression model to determine the factors that influence the nature of uses. The logistic regression or logit regression used for predicting the outcome of a categorical dependent variable (a dependent variable that can take on a limited number of values, whose magnitudes are not meaningful but whose ordering of magnitudes may or may not be meaningful) based on one or more predictor variables. That is, it is used in estimating empirical values of the parameters in a qualitative response model. The probabilities describing the possible outcomes of a single trial are modeled, as a function of the explanatory (predictor) variables, using a logistic function.

The logistic regression based on the logistic function, which always takes on values between zero and one:

$$f(t) = \frac{e^t}{e^t + 1} = \frac{1}{1 + e^{-t}},$$

and viewing t as a linear function of an explanatory variable x, we have:

$$\pi(x) = \frac{e^{(\beta_0 + \beta_1 x)}}{e^{(\beta_0 + \beta_1 x)} + 1} = \frac{1}{1 + e^{-(\beta_0 + \beta_1 x)}}.$$

We also define the inverse of the logistic function, the logit :

$$g(x) = \ln \frac{\pi(x)}{1 - \pi(x)} = \beta_0 + \beta_1 x,$$

and equivalently :

$$\frac{\pi(x)}{1 - \pi(x)} = e^{(\beta_0 + \beta_1 x)}.$$

The first formula illustrates that the probability of the dependent variable equaling 1 is equal to the value of the logistic function of the linear regression expression. This is important that it shows the input of the logistic regression equation (the value of the linear regression expression) can vary from negative to positive infinity and yet, after exponentiating the odds of the expression, the output will vary between zero and one. The third equation illustrates that the logit (i.e., log-odds or natural logarithm of the odds) is equivalent to the linear regression expression. Likewise, the fourth equation illustrates that the odds of the dependent variable equaling 1 is equivalent to the exponential function of the linear regression expression. This illustrates how the logit serves as a link function between the probability and the linear regression expression. Given that the logit ranges through the interval (0,1) it provides an adequate criterion upon which to conduct linear regression and the logit is easily converted back into the odds.

The model for the determinants of the nature of use (single or multiple use) was developed using the logistic regression model was fitted to the selected variables as below.

Y- Nature of use (single or multiple use)

D_1- Stocking of fish seed (1-Yes, 0-No)

D_2- Region (0-Coastal, 1- Interior)

D_3- Community management (1-Yes, 0-No)

D_4- Presence of temple, (1-Yes, 0-No)

X_1-Ln (annual family income),

X_2-Ln (population/land area in village),

X_3-Ln (number of fisheries users),

X_4- Ln (total area of households),

X_5-Level of dependence of fisheries

RESULTS AND DISCUSSION

Small multiple use water resources characterization

Till today, there is no clarity over size to distinguish between the large and small water bodies from aquaculture point of view. The water bodies need to be small enough for application of aquaculture technology as the principles of aquaculture cannot be applied to large water bodies. The large water bodies like rivers, reservoirs and lakes are utilized as the capture or culture based fisheries, where as the small water bodies are utilized for the culture fisheries or aquaculture (Sugunan, 1997). In the initial stage of aquaculture development an arbitrary value of 10 ha was considered as maximum size for aquaculture technology but it did not reflect reality as farmers are adopting water areas much beyond 10 ha for intensive aquaculture in certain areas of India. In the state of Odisha, 40 ha or less are considered as small water bodies and therefore brought within the ambit of local self government (Panchayats) for local management (Reservoir Policy of Odisha, 2004). In Odisha the systems of management for the water bodies with size less than 40 ha are different from larger water bodies. Therefore, in the present study the areas less than 40 ha are considered as small water bodies. For the present purpose, the small multiple use water bodies (MAR) have been taken as the water resources with water spread area less than 40 ha, generally under public domain which is used for multiple purposes by multiple groups. In addition to ponds and tanks, MAR also consists of water harvesting structures under watershed management schemes, small farm ponds, micro and minor irrigation project, dead river bed, backyard pond, check dams, percolation ponds, derelict water bodies, swampy lands etc. The scope of the MAR is presented in Fig. 1

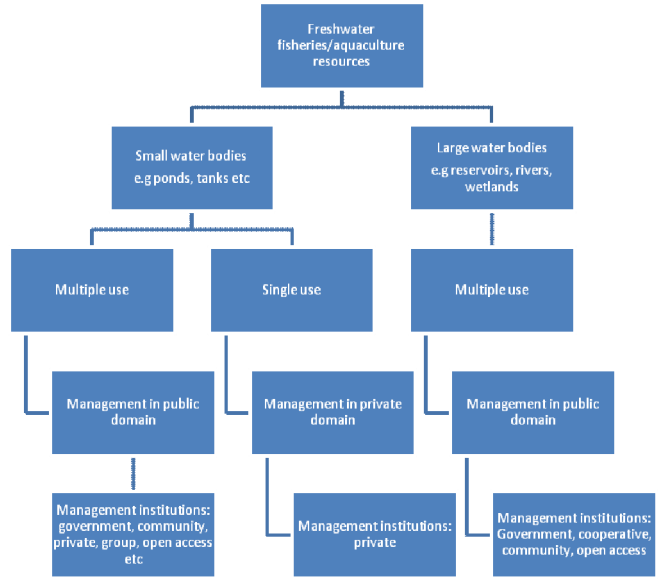

Fig. 1 : The scope of small multiple use fresh water aquaculture resources.

Institutional framework for management of aquaculture in multiple use water bodies

Institutional challenges for the management of aquaculture in the small multiple use water resources are quite large. The primary functions for the management are negotiation of the access, development of management institutions, formulation of operational rules, access to technology and resources, conflict resolution and benefits sharing etc. The provisioning and allocation are the twin challenges that need to be overcome by the management. The research across the globe has shown that the fish culture can be managed either as community, group or private based institutions (Dey and Prein, 2003; Anon, 2002, Garaway *et al.*, 2006 and Ostrom, 1999). In general, the areas where the private management is not a viable option, the community based system is the only way for managing it. Therefore, the framework of the management institutions is quite large and a large number of the institutional options are available for the management of aquaculture.

The primary data collected in the study showed that government was the predominant owner in 57 per cent of the WBs and about 19 per cent of the WBs were owned by village communities. The public water bodies not within the control of the government were controlled by the village communities. The private ownership, temple and NGO were other types of

Table 1 : Ownership and management among the sampled water bodies

Institutions	Sample No (N)			Percentage		
	Coastal	Interior	All	Coastal	Interior	All
Ownership						
Government	29	18	47	56.9	56.3	56.6
Village community	13	3	16	25.5	9.4	19.3
Temple	5	1	6	9.8	3.1	7.2
Private	4	9	13	7.8	28.1	15.7
NGO	0	1	1	0.0	3.1	1.2
Control						
Panchayat	28	10	38	54.9	31.3	45.8
Revenue Department	1	0	1	2.0	0.0	1.2
Irrigation Department	0	0	0	0.0	0.0	0.0
Fisheries Department	0	1	1	0.0	3.1	1.2
Forest Department	1	0	1	2.0	0.0	1.2
Village Community	16	12	28	31.4	37.5	33.7
Others	3	3	6	5.9	9.4	7.2
Private individual	1	5	6	2.0	15.6	7.2
NGO	0	1	1	0.0	3.1	1.2
SHG	1	0	1	2.0	0.0	1.2
Management						
Village community	37	3	40	72.5	9.4	48.2
Group	8	10	18	15.7	31.3	21.7
Individual	6	19	25	11.8	59.4	30.1

ownership constituted smaller portion of the sampled resources. These resources were controlled primarily by the Panchayats (45 per cent), village communities (38 per cent) and private (7 per cent) with remaining controlled by the Revenue Department, Fisheries Department, Forest Department, NGO and Groups. The various categories of the ownership and control were ultimately transformed into three categories of the management system i.e community based, group based and private management. In addition to the above, there was no management system over open access resources (Table 1). Similar arrangements are repated from the flood plain wetlands in India (Barik and Katiha, 2003)

Private management system : The legal framework in Odisha often encouraged private management of the MAR as the resource was considered as revenue generating avenue like mines, orchards where the government sought rent extraction. The process of open auction and preference for highest bidder make the private and powerful people accessible to the resources. But, due to short term nature of the tenure for 1 to 3 years, the private management was interested in exploiting and catching the fish to recover the maximum rent. The long term improvement of the resources as well as the enhancement of the aquaculture through application of the aquaculture technology like stocking, feeding etc. was often missing. In the system only few were benefited which often led to conflicts and there were resistance among the village community for the leasing out the water bodies for the private use.

Group based management system : In the recent times, the government has encouraged the Self-Help Groups (SHG) particularly women SHG to access to these resources and preference was given to about 20% of the water bodies in a local administrative unit or block. These groups consist of 11 to 17 members who could access the resource from panchayats and manage it for the aquaculture purpose. The women groups were undertaking the activities like stocking, guarding, harvesting and selling of fish. Till now, the level of technological interventions was very low. The women groups were able to assert their rights and control over the resources with the support from the community and

panchayats. The level of conflicts in the group based management was lower compared to the private management due to support of villagers. In many ponds, the women were undertaking the functions like discussion with the technical experts, guarding the fish in the night from poaching, selling and account maintenance. Such group activities were on the rise in the rural areas of the state of Odisha.

Community based management : The legal framework did not recognise the community based management system for the aquaculture management and access to the resources were given either to the private or group. In such cases, there were considerable amount of resentment and conflict due to lack of legitimacy in the process. The community asserted the *de facto* customary rights over the resources and in many cases the community had taken over the MAR for aquaculture. In few cases, the community pressurized the panchayat to withhold the leasing process or take the lease in the name of a nominated member by the village community. In such cases, the lease value was quite low and the nominated members used to work on behalf of the community as legal lessee with *de facto* control by the community. Various types of institutions were created by the community for management of the aquaculture *viz*. formation of the village executive committee, selection of president and secretary, creation of the management group, rules for contributions, sharing arrangements, saving, expenditure etc. These institutions acted towards improvement of the aquaculture. The fish produce were shared in the diverse way. In general, the surplus fund from the aquaculture was used for the community purposes like annual village functions, temples, roads or support to poor. The village community were given 1 to 2 kg of fish in each harvest from organised harvest whereas small fishes were allowed to be caught openly by the community. These systems were found to be more equitable and sustainable but levels of production were low. The support from the government was quite low on such system due to lack of support from the legal regimes. The benefits available to the aquaculturists were not available to them leading to poor level of technological application and low productivity. Even with the low output and productivity, the community benefits from the water bodies were quite large and the levels of conflicts were quite low.

Determinants of multiple use of water resources (Logistic model)

The results of the logistic model with dependent variable as dichotomous variable (Single use/multiple use) is modeled with the selected variables are presented in Table 2 and 3. The selected variables were found to be significant in determining nature of use with a high level of predictability. Such result challenges the assumption that the nature of such use is static and does not change with the context.

Table 2 : Predictability of the model: determinants of multiple use of water bodies

Variables	Observed (N)	Predicted	Percentage Correct
Single use	18	14	77.8
Multiple use	35	31	88.6
Total	53	44	84.9

Table 3 : Logistic Model of determinants of multiple uses

Dependent variable = Multiple use (1), Single use (0)

Independent variables	B	Wald	Sig.
Stocking dummy (stocking 1, No stocking 0)	– 6.81	4.73	0.03
Ln (annual family income)	5.01	4.41	0.04
Ln (population/land area in village)	6.03	3.39	0.07
Ln (number of fisheries users)	2.20	4.07	0.04
Region dummy (Coastal-1, interior-0)	1.36	0.25	0.62
Community dummy (community management-1, others -0)	6.90	4.43	0.04
Ln (total area of households)	–2.43	3.76	0.05
Presence of temple dummy (yes-1, No-0)	3.69	4.18	0.04
Level of dependence of fisheries	–2.13	2.95	0.09
Constant	–1.49	0.16	0.69
Chi-square	45.3	-2 Log likelihood	22.63
Df	9	Cox and Snell R^2	0.58
Sig.	.00	Nagelkerke R^2	0.80

The model predicted about 85 per cent of the cases with Nagelkerke R^2 of 0.795 is an indication of the high degree of relevance of the fitted model in explaining the nature of the use of the water bodies under the study. The explaining variables for the multiple use are described as below.

Stocking dummy (stocking 1, No stocking 0) : Stocking or release of fish seed in the WBs is captured through this dummy variables. The stocking is the first and most important step for the aquaculture as the stocking in the pond indicates the use of the resources. The variable is significant but with negative coefficient indicating that the aquaculture tends to reduce multiple-nature resulting in single use. In other words, the aquaculture is related more with the single use of these water resources. Conversely, the aquaculture is more when the multiple-nature of the water bodies has been declined.

Ln (annual family income) : The annual family income has a positive coefficient indicating that possibilities of multiple use of water are more in the villages with relatively richer people. With the general economic development and increase in the income, nature of the multiple use of the water bodies is going to increase. Hence in future, the water bodies will be subjected to more uses.

Ln (population/land area in village) : This measures the population density as number of people per unit land areas in the village. With increase in the measures, the scarcity of the land resources increase. With increase in the scarcity the use of the water bodies has been found to be intensified. In the future, with increase in the population the multiple use nature of the water bodies will increase and populace will find more uses of it.

Ln (number of fisheries users) : The number of fisheries users is found to be positive in coefficient i.e. more of the fisheries users are found in the multiple use water bodies. When such water bodies are used for fisheries, a large number of people are benefited.

Region dummy (Coastal-1, interior-0) : The coefficient of region dummy is positive in favour of the coastal areas means; the more of the water bodies in the coastal areas were put under multiple use. The average sizes of the water bodies in these region are less than in interior areas. The less water areas, high population, scarcity etc are the characteristics of the coastal areas which are expected to have more of the multiple use resources.

Community dummy (community management-1, others - 0) : The community management dummy is found to be statistically significant. Therefore, the community managed WBs are more subjected to multiple-use whereas the privately managed water bodies tend more towards single use. Primarily, the single use in such cases happens to be the fish culture. In others words, the multiple use water bodies when used for fisheries purposes, mostly need the community management system. Therefore, as a matter of principle and convinience, the multiple use resources need to be placed for the community management as appropriate model for the effective management.

Ln (total area of households in acre) : The total area of household in acres has a negative coefficient indicating that, when the size of land holding of the households in the villages are more, then the probabilities of the single use water resources are more. In other words, when the villages do have more land for the people, more number of water bodies are used for single use. Hence, with less land, the multiple use nature of the WBs increases.

Presence of temple (dummy: Yes-1, No-0) : The presence of the temples is also associated with the multiple use of the WBs. Most of the temples in the villages are located near community ponds as the religious use of the WBs are closely related with the temples. Moreover, the temples are primarily built by the village communities, therefore, they are the indicators of collective action in the village. Such condition favors multiple-use of the WBs.

Level of dependence of fisheries : Level of dependence on fisheries by the household is found to be negative in the model as higher dependence was related to single use of the resources. In other words the users of the fisheries are depending less on the multiple use WBs. Moreover, as the multiple

use WBs are governed primarily by the community management with large number of stakeholders sharing the common benefits, the level of dependence for livelihood is lesser. On the other hand, when few people manage the single use water resources, the level of dependence increases.

The present study is based on the informations collected from the public and community owned water bodies. The nature of the uses of these water bodies varies substantially. Within the domain of the water bodies, there are multiple and single use of it. The factors like land and water scarcity, economic development, community management, number of users, collective assets in the village etc. are the contributing factors for the multiple-use. For more of the fisheries, smaller number of users, high level of dependence and higher land holding size in villages are found to be associated with the single use of these water bodies. In future, with the increase in the population, resources scarcity and economic development these water bodies will be subjected to more of multiple use. But, the fisheries development are happening more in the single use resources. Hence, greater negotiations and accommodation is required at the community level to encourage fish culture in the multiple use ponds.

CONCLUSION

Among many water uses, aquaculture is considered as a low consumption high value use. The direct consumptive use for fish farming is low but it requires a particular amount of water. On the other hand due to high price of fish, the economic return from the aquaculture is very high. Hence, there is a considerable scope for integration of the aquaculture in the water bodies. But, the institutional constraints are major bottlenecks in the aquaculture development. A diverse range of institutional set up is found to be associated with aquaculture which can primarily be categorized as community, group and privately managed. The nature of use of the water is determined by a wide range of variables viz, stocking of fish seed, scarcity, population pressure, income, land area of household, management system, collective action and level of dependence on the water resources. The paper showed the diverse factors determining the promotion of aquaculture. Hence, appropriate institutional framework needs to be developed for the better management of aquaculture in the multiple use water resources.

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AMPUTATION OF HIND LIMB IN A SPOTTED DEER (*Axis axis*)

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ABSTRACT

One full grown adult male spotted deer (*Axis axis*) weighing about 120 kg was presented at forest range office Chandaka with a history of severely infective wound near its right metatarso-phalangeal joint and multiple injuries on the antler. On clinical examination, a badly infected wound with dead and necrosed soft tissues were observed around the compound fracture site. Injured antlers were bandaged after necessary dressing. It was decided to amputate the hanged portion of the wounded leg under general anaesthesia. A cocktail mixture of 2.4 ml. of Xylazine HCl and Ketamine HCl was injected in the proportion of 0. 5 mg/kg body weight and 1.5 mg/kg body weight respectively. The wound site was properly cleaned. The dead and necrosed part of bone and soft tissues were cleaned. The hanged portion of the leg was excised above the affected joint. Antibiotic powder (Chloromycetin) sprayed into the site. The skin flaps were stitched with mattress sutures. Yohimbine HCl was given intra-veinously with the dosage of 1 mg/kg body weight. There was graceful reversal. The animal was recovered after 3 minutes. Post-operatively antibiotics and analgesics were administered to control pain and infection. Regular wound management was taken care of. Isolation, minimal disturbance and confinement with minimum ambulation were adopted for quick recovery. On 15th post-operative day, the sutures were removed and thereafter, the animal received a unique conformational change on due course of time for its weight bearing and gait.

Key Words : Limb amputation, metatarso-phalangeal joint, rehabilitation, suture, wound, confinement

INTRODUCTION

The musculo-skeletal injuries of the appendages are commonly encountered in wild cervids which make them an easy prey to predators or they may succumb to death due to ascending infection. Fracture of the forelimb, hind limb and pelvis are relatively common in antelopes as they are routinely attacked by the predators (Kachiwal, 2010). Treatment of injuries in wild and captive animal possesses problems for veterinarians mainly in controlling the injured animal and in preventing self mutilation (George *et al.,* 1986). Extensive injuries resulting in complicated fracture with damages to muscles, blood vessels and nerves lead to loss of limb. Some cases of compound fracture get complicated due to microbial infection, in which limbs have to be amputated to save the animal. By that the animals are relieved from severe pain and also the recovery is faster. Limb amputation is a salvage procedure for open, infected, irreparable injuries and complicated fractures and is widely practiced in cats, dogs and human beings; however, the literature is scanty concerning limb amputation in wild cervids (Singh *et al.,* 2010). Amputation may be a life-saving procedure for the animals and a procedure that can minimally impact their comfort and quality of life (Crawley *et al.,* 1989). The present report describes the successful rehabilitation of a spotted deer following its surgical management of the severely wounded leg.

MATERIALS AND METHODS

One male spotted deer (*Axis axis*) weighing about 120 kg body was rescued by forest department and kept besides a makeshift room of Divisional Forest Office at Rental colony besides Bharatpur jungle, Bhubaneswar. Surgery experts were invited from Odisha Veterinary College, 3 kms away from the site. The author and his team from wildlife background decided to treat the animal then and there. It was observed that the room was properly disinfected and there was least disturbance to the animal. The badly infected and severely wounded leg with dead and necrosed tissues was observed around the open

fracture site (Fig.1). The region below the metatarso-phalangeal joint was cold to touch with signs of least vascularisation. The wounded part in hanging state was supported with a thin musculo-cutaneous (superficial and deep digital flexor tendon) attachment. To know the extent of infection and the type of fracture, C-arm examination was done which revealed complete fracture with signs of osteomyelitis and peri-osteal reactions. The wound was cleaned and dressed under aseptic measures with application of betadine liquid . Chloromycetin powder (Paraxin cap) sprayed into the site. Analgesic (meloxicam 0.2 mg/kg I.M.) and antibiotics (Ceftriaxone 10 mg/ kg I.V.) were administered to control the pain and infection. The injured antlers were dressed aseptically and bandaged (Fig.2). The limb amputation was scheduled after three days of regular dressing and medication.

The animal was withheld water and food for 12 and 24 hours respectively prior to the surgery. Anaesthesia was induced by administration of cocktail of 2.4 ml of Xylazine HCl and Ketamine HCl (Troy Labs PTY Ltd., Smith field, NSW, Australia) in the proportion of 0. 5 mg/kg body weight and 1.5 mg/ kg body weight respectively. Fluid therapy was maintained. The affected site was shaved, cleaned and prepared for aseptic surgery. For skin incision, factors like vascularity of the site, flexion and extension direction of the part and the point of ground contact of the future stump were taken in to consideration. Every attempt was made to keep the skin-fasciae-muscle attachments undisturbed. On the medial and lateral sides, the attachments of muscles were separated along their cleavage lines in order to expose the bone above the level of wound. Blood vessels were ligated and the dead part of metatarsal bone was detached by bone cutter. Muscle, fascia and skin were sutured for avoiding formation of a conical stump. Muscle flap from one side was drawn over the bone and was sutured to the opposite muscle groups with several interrupted sutures using polyglactin 910 (No.1). Skin flaps were apposed with mattress and interrupted sutures and covered with a thick antiseptic pad (Fig.3 and 4). Reverzine (Yohimbine Hydrochloride) 1.2 ml from Parneli Labs PTY Ltd., Alexandria, NSW, Australia at the dosage of 1 mg/ kg was administered intra-veinously. The animal was recovered after 2 minutes. Antibiotics Ceftriaxone @ 10 mg/kg intravenously and Meloxicam @ 0.2 mg/kg intramuscularly were administered for 7 and 5 days respectively. Along with these local application of fly repellent were recommended. The animal was housed inside a closed confinement with soft bedding and restricted movement in order to give less pressure on the suture lines for quick healing.

RESULTS AND DISCUSSION

Treatment of fractures in non-domestic animals is a challenge as regular follow ups are not practically possible, frequent restraining is not advisable and also it is difficult to restrict an animal's movement during the post-operative period (Kumar, 2006). Amputation is looked upon as a drastic therapy that should be considered only when all other methods of treatment have failed. Though amputation is a last resort, the decision to perform surgery must be made before any pathological changes can occur in the contra-lateral limb (Crawley *et al.,* 1989). In the present report the fracture was irreparable, infected, severely wounded and open, so amputation was the last choice. The animal was able to stand on the next day by three legs after surgery and began walking on the 5th postoperative day. On 15th post-operative day the sutures were removed and observed that the wound was completely healed up. During the course of time (2 months) the end of the amputated limb was modified to a unique muscular rounded shape, which enabled the animal to walk and bear weight (Fig.5 and 6). By this time, the animal regained its ambulation and beauty which was lost after being severely wounded and further amputation. Finally, the animal was rehabilitated in the Nandankanan Zoological Park. The deer remained

Fig. 1 : Severely wounded leg with necrosed and soiled tissue at the time of presentation.

Fig. 2 : Bandaging of multiple injured antler.

Fig. 3 : Bandaging after excision of wound part.

Fig. 4 : Maintenance with fluid therapy.

Fig. 5 : Comparing both the limbs after complete healing.

Fig. 6 : Rounded conformational change of the limb with regaining padded bottom.

in the zoo with close supervision owing to its slow walking and running.

Anesthesia in the present case was successfully managed with Xylazine and Ketamine hydrochloride combination. It was found effective during surgery. Recovery was graceful with intra-veinous administration of Yohimbine HCl. It corroborates with the study conducted by Nigel (2001) and Kumar *et al*. (2012). Kumar (2006) had managed a simple fracture of the metacarpus in a blackbuck by external immobili-zation, isolation, minimal disturbance and containment near a deer enclosure that was separated by a chain-link partition. Similarly, Singh *et al*. (2010) used a chain-link partition with 200 yd^2 confinement area to restrict the movement of the deer in order to protect the suture line. In the present case, it was also kept in the confinement with soft bedding for fast healing. Limb amputation can be considered a viable alternative to euthanasia when catastrophic orthopaedic injuries occur in wild animals. An animal that has undergone limb amputation can be successfully given a normal-as-possible confined life where it is protected from predators as long as specific management changes are made to accommodate ambulation in an appropriate manner (Singh *et al*., 2010). It is herewith inferred that the amputation of limb is sometimes required and becomes inevitable in wild animals where there is no substitution for preserving the wounded part.

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ASSESSMENT OF GENETIC DIVERSITY IN NIGER (*Guizoita abyssinica* L.F. Cass)

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ABSTRACT

The results obtained from the genetic divergence studies in niger of 40 genotypes carried out during Kharif, 2011-12 and 2012-13 and pooled data was utilized for estimation of genetic divergence. The study revealed that, the D^2 values ranged between 0.23 (IGPN-9001 and JNS-505) to 290.52 (JNS-501 and IGPN-08-20) suggesting the presence of considerable amount of genetic diversity. The genotypes studied were grouped into seven clusters, in which cluster I (23) was largest among all followed by cluster II (6), cluster III (4) and cluster V (4) and cluster IV, Cluster VI and cluster VII are monogenotypic. The maximum intra cluster distance was observed for cluster V (D^2 = 4.44) followed by, cluster I (D^2 =3.02), cluster II (D^2 = -1.69), cluster III (D^2 = 1.59), while the negligible intra cluster distance was observed in cluster IV, VI and VII (D^2 = 0.00). Whereas, the maximum inter cluster distance was observed between cluster II and III (D^2 = 16.30), followed by cluster II and VII (D^2 = 12.12), cluster III and V (D^2 = 11.94). Cluster III and VI (D^2 =11.18). The above study shows that, these genotypes are having maximum genetical variation. On the basis of intercluster distance and cluster means the genotypes viz., IGPN-08-20, JNS-501, JNS-3, JNS-508, JNS-502, JNS-10, IGPN-08-19, IGPN-08-16, LNC-7, JNS-165 were identified for their use in hybridization programme.

Key words : Genetic diversity, D^2 analysis, niger, genotype

INTRODUCTION

Niger (*Guizotia abyssinica* L.F. Cass) is mostly grown in tribal areas in India, it is considered as lifeline of tribal agriculture and economy. It is an important crop and has got the potentiality to give sustainable yield under rainfed situation. It is cultivated in kharif season, mainly in low rainfall areas. It is grown on marginal, unproductive, waste lands without any production management. The moisture holding capacity of these lands is such that, the crop often suffers severe moisture stress during their life span. Diversity is the basic need of crop improvement programmes. The success of any crossing programme depends on selection of parents having high expression for the economically important characters. Among the different approaches of selecting parents, selection based on diversity has its own merit. Therefore, in the present investigation diversity among different genotypes was studied, which yielded valuable information that could be useful in suggesting potent parents for crossing. A very, limited work of this kind has been done on niger. Selection of elite genotypes with high per se performance for yield and yield contributing characters with genetic divergence is important for exploitation of heterosis and population improvement programmes. It would be possible to identify desirable genotypes from the estimates of genetic variability but it is difficult to expect any extraordinary results from their progeny unless we sincerely analyze the divergence between them.

MATERIALS AND METHODS

Forty genotypes of niger (*Guizotia abyssinica* L.F. *Cass*) from different geographic origins and showing phenotypic variability for agronomic and yield characters were studied. The material for the present investigation comprised forty accessions of niger, ten genotypes obtained from Zonal Agricultural Research Station, Igatpuri, MPKV, Rahuri (Maharastra), seven genotypes obtained from Project Coordinating Unit, Jabalpur (MP), nine genotypes are from Zonal Agricultural Research Station, Nehru Krishi Vishwa Vidylaya, Chhindwada (MP), ten genotypes are from Chikhaldara Ghat, Melghat, Amravati (AP), four genotypes are from Ghat Region, Nandurbar(Maharastra). The present study was conducted during Kharif, 2011-12 and 2012-13 and pooled data was utilized for estimation of genetic divergence. The experiment was laid out in randomized block design with three replications. Those were evaluated for 10 characters *viz.*, days to 50 per cent flowering, days to maturity, plant height (cm), diameter of capitula (cm), number of branches per plant, number of capitula per plant, number of

seeds per capitula, 1000 seed weight (g), seed yield per plant (g), oil content per cent (%). The analysis of divergence was carried out by D^2 statistic proposed by Mahalanobis (1936) as described by Rao (1952). Multivariate analysis is one of the important biometrical tools for quantifying the degree of divergence among different genotypes.

RESULTS AND DISCUSSION

In the present investigation, D^2 values between all possible pairs of 40 genotypes ranged between 0.23 (IGPN-9001 and JNS-505) to 290.52 (JNS-501 and IGPN-08-20) are studied. The high range of D^2 values showed the presence of good amount diversity in the material used for current study. The 40 genotypes studied were grouped into seven clusters (Table 1) by using Tocher's method as described by Rao (1952). Cluster I with 23 genotypes emerged as the largest cluster followed by cluster II with six genotypes and cluster III and cluster V both with four genotypes. Cluster IV, VI, VII were monogenotypic consisting of JNS-10, IGPN-08-16 and JNS-8, respectively. These genotypes included in the above monogenotypic clusters had wide variations from the rest as well as from each other. These genotypes may have different architecture from the others. In the present study grouping of genotypes into seven clusters, itself indicate wide diversity among genotypes. Mehta (1989), Jagadev and Samal (1991), Biswas, *et al.* (1993), Ravanappa and Sheriff (1994), Sreedhar *et al.* (2006) and Paramesharapa, *et al.* (2009 and 2011) have reported more clusters in their study. The average intra and inter cluster distances, D^2 values are presented (Table 2). The range of intra cluster distance was observed from 4.44 to 0.00. Among all intra cluster values cluster V (D^2 = 4.44) had highest value followed by cluster I (D^2 = 3.02), cluster II (D^2 = 1.69) and cluster III (D^2 = 1.59); while the negligible intra cluster distance was observed in cluster IV, VI and VII (D^2 = 0.00). The maximum inter cluster distance was observed between cluster II and III (D^2 = 16.30), followed by cluster II and VII (D^2 = 12.12), cluster III and V (D^2= 11.94) and cluster III and VI (D^2 =11.18). This showed that, these genotypes were having maximum genetical variation. While, minimum inter cluster distance was found between cluster I and V (D^2 = 4.12), followed by cluster I and IV (D^2 = 4.39), cluster I and VI (D^2 = 4.75) and cluster IV and V (D^2= 4.89). The lower value of D^2 = 4.12 between cluster I and V suggested that the genotypic constitution of such genotypes in cluster I was in close proximity with the genotypes in cluster V.

Table 1 : Distribution of 40 genotypes into different clusters.

Sr. No.	Cluster number	Total no. of genotypes in each cluster	Genotypes included in the cluster
1	I	23	IGPN-9001, JNS-505, IGP-76, LNC-8, JNS-14, LNC-11, IGPN-08-18, JNS-502, IGPN-8007, LNC-9, JNS-6, Birsa Niger-3, LNC-5, LNC-6, LNC-4, LNC-7, LNC-13, IGPN-08-14, LNC-12, LNC-1, LNC-3, LNC-2, JNS-503.
2	II	6	IGPN-8002, Birsa Niger-1, IGP-76, JNS-501, JNS-164, JNS-1.
3	III	4	JNS-165, JNS-508,LNC-14,IGPN-08-20.
4	IV	1	JNS-10.
5	V	4	IGPN-08-19, JNS-13, LNC-10, JNS-3.
6	VI	1	IGPN-08-16
7	VII	1	JNS-8

Table 2 : Average intra and inter cluster D^2 for ten characters in Niger genotypes.

	Cluster I	Cluster II	Cluster III	Cluster IV	Cluster V	Cluster VI	Cluster VII
Cluster I	3.02	8.07	10.52	4.39	4.12	4.75	6.00
Cluster II		1.69	16.30	9.41	7.18	8.68	12.12
Cluster III			1.59	9.48	11.94	11.18	5.49
Cluster IV				0.00	4.89	6.49	5.32
Cluster V					4.44	6.38	7.64
Cluster VI						0.00	6.61
Cluster VII							0.00

The lower D^2 values between these clusters suggested that the genetic constitution of the genotypes in one cluster were in the close proximity with genotypes in other cluster of pair. The three monogenotypic clusters showed zero intra cluster distance. Based on the mean performances of the cluster for ten characters (Table 2), cluster II found to be the least yielder. It comprised of six genotypes, *viz.*, IGPN-8002, Birsa Niger-1, IGP-76, JNS-501, JNS-164 and JNS-1, having earliness, less number of branching, number of capitula per plant, number of seeds per capitula and 1000 seed weight as compared to genotypes belonging to rest of the clusters. Low seed yield per plant by these genotypes can be attributed to lesser number of capitula per plant (40.58), diameter of capitula (0.84 cm), number of branches per plant (8.31) number of seeds per capitula (9.24) and 1000 seed weight (2.76 g).

Cluster VII was monogenotypic having 4.56 g mean seed yield per plant. This may be due to high number of branches per plant, number of seeds per capitula, number of capitula per plant, 1000 seed weight as compared to cluster II genotypes.

Cluster III, the most important cluster, which comprised of four genotypes, in general included the most productive, late maturing genotypes with tall height, more number of branches, more number of capitula per plant, number of seeds per capitula and good oil content per cent (39.83%). Mean seed yield per plant of this cluster was 5.01g. The cluster mean for all ten characters are presented in Table 3. A considerable inter cluster variation was observed among the days to 50 per cent flowering, days to maturity, plant height, number of branches per plant, diameter of capitula, number of capitula per plant, number of seeds per capitula, 1000 seed weight, seed yield per plant and oil content per cent.

The cluster mean observed for days to 50 per cent flowering is varied from 68 (cluster II) to 86.38 (cluster III). The cluster mean for days to maturity is varied from 97.50 (cluster IV) to 115.38 (cluster III). Cluster mean for plant height is varied from 145.08 cm (cluster II) to 184.41 cm (cluster III). The cluster mean for number of branches per plant is varied from 5.41 (cluster VI) to 13.35 (cluster III). The cluster mean of diameter of capitula ranged from 0.84 cm (cluster II) to 1.05 cm (cluster IV). The cluster mean for the number of capitula per plant is varied from 40.58 (cluster II) to 105.64 (cluster III). The cluster mean for number of seeds per capitula is varied from 9.24 (cluster II) to 27.09 (cluster III). In case of 1000 seed weight, it was minimum 2.76 g in cluster II and maximum 3.55 g in cluster VI. The cluster mean for seed yield per plant is varied from 1.81 g (cluster II) to 5.01 g (cluster III). In case of oil content per cent cluster mean varied from 37.66 (cluster II) to 40.32 % (cluster IV). Hence, cluster diagram of niger genotypes are presented in Fig. 1.

The contribution of the characters towards genetic divergence was presented in Table 4. It indicated that among various characters studied, number of seeds per capitula was (27.95 %), contributed more to genetic diversity. However, plant height (0.64 %) contributed least to the divergence, followed by number of capitula per plant (5.00 %), number of branches per plant (5.90 %). Ravanappa and Sheriff (1994) observed that number of capitula per plant, 1000 seed weight, oil content percent and seed yield per plant have contributed more to divergence. Kumar (1999) reported that days to maturity has maximum contribution towards divergence. Sreedhar *et al.* (2006) and Parmeshwarappa *et al.* (2009) were also of same opinion.

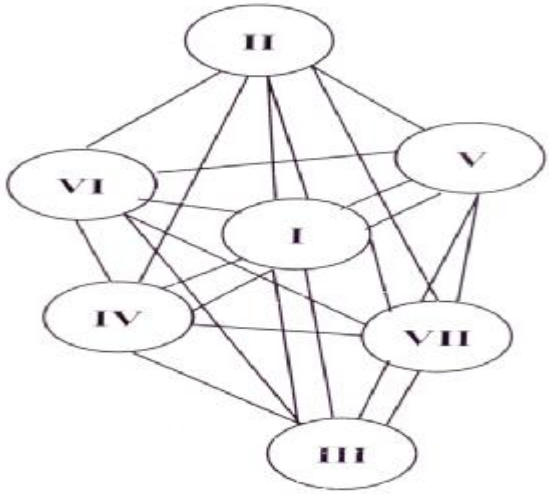

Fig. 1 : Cluster Diagram for 40 Niger genotypes

Table 3 : Cluster mean for ten characters under study in niger.

Cluster No.	Days to 50 % Flowering	Days to Maturity	Plant Height (cm)	No. of Branches per plant	No. of Capitula/ Plant	Diameter of Capitula (cm)	No. of Seeds / Capitula	1000 Seed Weight (g)	Seed Yield / Plant (g)	Oil %
Cluster I	71.23	99.26	159.61	9.62	45.63	0.89	13.56	2.73	2.13	37.90
Cluster II	68.00	102.35	145.08	8.31	40.58	0.84	9.24	2.76	1.81	37.66
Cluster III	86.38	115.38	184.41	13.35	105.64	0.90	27.09	2.99	5.01	39.83
Cluster IV	75.34	97.50	162.64	10.23	51.23	1.05	16.95	3.30	2.46	40.32
Cluster V	74.62	112.91	169.40	9.63	76.32	0.95	19.42	3.26	3.65	38.25
Cluster VI	85.11	109.56	162.53	5.41	89.45	1.01	22.45	3.55	3.13	38.64
Cluster VII	82.47	108.61	174.68	7.66	99.62	0.99	26.41	3.49	4.56	39.44

Table 4 : Percent contribution of characters into total divergence.

Sr. No.	Characters	Times ranked 1St	Percent contribution
1	Days to 50% flowering (days)	110	14.10
2	Days to maturity (days)	62	7.95
3	Plant height (cm)	5	0.64
4	No. of branches per plant	46	5.90
5	No. of capitula per plant	39	5.00
6	Diameter of Capitula (cm)	56	7.18
7	No. of seeds per capitula	218	27.95
8	1000 seed weight (gm)	97	12.44
9	Seed yield per plant (gm)	49	6.28
10	Oil % content	98	12.56

Table 5 : Tentative suggested crossing programme in future.

Sr. No.	Characters to be improved	Cluster combination	Possible crosses
1.	No. of capitula per plant	(III,IV)	LNC-14 x JNS-10IGPN-08-20 x JNS-10
		(II,V)	JNS-501 x IGPN -08-19JNS-501 x JNS-3
2.	No. of seed per capitula	(V, VI)	JNS-3 x IGPN-08-16
		(V,VII)	JNS-3 x JNS-8
		(IV,VI)	JNS-8 x IGPN-08-16
3.	Seed yield per plant	(III, IV)	LNC-14x JNS-8JNS-508 x JNS -8 IGPN-08-20 x JNS-8
		(IV,VI)	JNS-8x IGPN-08-16
		(I, V)	JNS-502 x JNS-3 LNC-7 x IGPN -08-19

The overall perusal of research investigation indicated that the genotypes on the basis of inter cluster distance, cluster means and per se performance, the genotypes viz., IGPN-08-20, JNS-501, JNS-3, JNS-508, JNS-502, JNS-10, IGPN-08-19, IGPN-08-16, LNC-7 and JNS-165 were highly diverse and hence these may be utilized in future breeding programme (Table 5) for creating maximum spectrum of variability for different yield contributing characters which will facilitate to develop superior genotypes with respect to more than one characters and also possible to improve more than one character, simultaneously.

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ASSESSMENT OF DIFFERENT NUTRIENT MANAGEMENT MODULES FOR SUNFLOWER (*Helianthus annuus* L.) CROPPING IN PLATEAU ECOSYSTEM

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ABSTRACT

Field experiments were conducted during rabi 2010-11 and 2011-12 in Deogarh district of Odisha to assess the best nutrient management module for sunflower (*Helianthus annuus* L.) cultivation in plateau eco-system. Four treatments i.e., farmer's practice (FP) [T_1], Recommended dose of fertilisers (RDF), i.e., 60:80:60 NPK kg/ha + 5 tn Farm Yard Manure(FYM)/ ha + 50%N as top dressing (T_2), RDF + Paper Mill Sludge(PMS) (5q/ha) + Gypsum (2.5 q/ha) (T_3), RDF + PMS (5q/ha) + Gypsum (2.5 q/ha) + Boron (10kg/ha) as soil application (T_4) were taken with five replications, each in 0.4 ha of land. The most effective vegetative growth as well as yield performance was reported in T_4. The yield and Benefit Cost Ratio (BCR) of T_4 was 15.3 q/ha and 2.95 in comparison to 9.2 q/ha and 2.37 in T_1 respectively. The best module (T_4) produced higher yield of 66.3%, 167.5%, 63.8% and 124.0% respectively over farmer practice, district yield, state yield and the national yield.

Key words : Sunflower, plateau ecosystem, vegetative growth, yield, economics

INTRODUCTION

Sunflower crop (*Helianthus annuus* L.) was introduced to Indian agriculture during 1969 to bridge the demand-supply gap of edible oil in the nation(Nath and Barik, 2011). Within these 40 years it is designated as one of the most popular oilseed crops of the farming community. Now it is the fourth most important oilseed crop in the nation after groundnut, rapeseed-mustard and soybean. Oil quality of sunflower is high due to presence of some useful fatty acids in it (Rodriguez *et al*. 2002). Its composition of about 13% saturated fats, 27% mono unsaturated fats and 60% poly unsaturated fats considers it as one of the best recommended edible oil for human consumption (Ghafoorunissa and Krishnaswamy, 2000). Its quick and better adoption among the farmers is for its special attributes like short duration, photo period insensitiveness, drought resistance, adaptability to varied range of agro-climatic and eadaphic situations besides the rich source of of high quality edible oil in it (Shesa and Sridhar, 2005). After introduction, the crop was more adopted in the irrigated areas, plain lands with conducive climate. Gradually it became popular in most of the agro-climatic zones of the nation. Through special programmes like technological mission on oilseeds (TMO, 1986) of the Government of India, special attention was given to increase its production potential. Karnataka, Andhra Pradesh, Tamilnadu and Maharastra are now the major sunflower producing states with about 90 per cent of the total cultivated area having 72 per cent of total production (2007-08). Efforts are taken by other state governments to popularize it with scientific cropping practices in different agro-climatic zones and in different farming situations.

Deogarh district, situated at 21^0 11' -$21^0$43' E latitude and 84^0 28' -$85^0$15' N longitude represents the North-Western agro-climatic zone of Odisha. The district is an extension of Chhotanagpur plateau with 52 per cent of total geographical area covered under hills and mountains. Only one-third of the total cultivated area of the district is irrigated which reduces to less than 25 per cent during the rabi season. About 80 per cent of total normal annual rainfall of 1582 mm comes in kharif season. It leads the scope of sunflower cropping during rabi and early summer season. The yield of the crop is far less in this district

i.e., only 5.72 q/ha, in comparison to state average of 9.34 q/ha and national yield of 6.83 q/ha (2008-09). Keeping the low yield of the district in view, the experiment was undertaken to assess the performance of the crop under various nutrient management practices in plateau eco-system.

MATERIALS AND METHODS

The experiments were conducted during rabi 2010-11 and 2011-12 at Kailash village of Deogarh district. Four treatments were taken in 0.4 ha plot of five farmers. pH of the soil of the plots were found to be in the range of 5.6 - 6.2. Their average fertility status was N 282 kg/ha, P_2O_5 24.8 kg/ha and K_2O 180.9 kg/ha. The experiments were carried out in 4 treatments i.e.,farmer's practice(T_1), recommended dose of fertilisers (RDF), i.e., 60:80:60 NPK kg/ha + 5 t FYM/ha + 50%N as top dressing (TD) (T_2), RDF + Paper mill sludge (PMS) (5q/ha) + Gypsum (2.5 q/ha) (T_3) and RDF + PMS (5q/ha) + Gypsum (2.5 q/ha) + Boron (10kg/ha) as soil application (T_4). The popular sunflower variety KBSH-1 hybrid was taken for yield assessment. Rathod *et al.* (2002) and Varaprasad *et al.* (2006) reported that hybrids are popular as they are more vigorous, uniform, self-fertile and resistant to pests and diseases. Bio-metric observations were taken at every 30 days interval after sowing. The economics was calculated to show the benefit of the best nutrient management module.

RESULTS AND DISCUSSION

In all the treatments and replications, plant height (cms) and number of leaves were recorded at 30, 60 and 90 days after sowing (DAS) as shown in Table 1.

Table 1 : Vegetative growth of the crop (Pooled data of two years)

Treatments	30 DAS		60 DAS		90 DAS	
	Plant height (cm)	Leaves (no.)	Plant height (cm)	Leaves (no.)	Plant height (cm)	Leaves (no.)
T_1	26.5	10.9	117.9	24.4	119.5	17.9
T_2	37.2	17.4	139.6	33.2	148.2	24.7
T_3	38.1	18.7	140.2	33.7	150.6	26.0
T_4	37.9	18.1	142.3	34.6	153.1	26.5
CD(P=0.05)	3.67	2.68	8.25	4.67	9.34	4.81

From the above table it is observed that application of fertiliser without soil testing (T_1) produced the least numbers of leaves in all the three stages. While taking observations similar trend was found in the plant height at 30, 60 and 90 days after sowing. The growth of plant was more during the period 30 to 60 DAS which was reduced after 60-70 DAS. Sarkar *et al.* (2005) studied that in sunflower crop maximum growth occurs during 50 to 70 days in all the treatments. Under the study, decrease in crop growth rate towards maturity was due to senescence of older leaves. Similarly, the number of leaves also started reducing after 60 DAS. In T_2, T_3 and T_4 the plant height and number of leaves were almost equal in the initial stages. But the most effective plant growth was recorded in T_4. Table-1 indicated that recommended dose of fertiliser (60: 80: 60 kg NPK/ha) played the most important role in vegetative growth of sunflower plants. Devidayal and Agrawal (1999) corroborate the above study. The yield parameters of all the treatments were analysed and mentioned in Table 2.

Table 2 : Yield performance under different modules of nutrient management (pooled data of two years)

Treatments	Capitulum diameter (cm)	100 seed weight (gm)	Filled seed (no.)	Unfilled seeds (no.)	Yield (q/ha)
T_1	12.6	3.6	184.2	188.5	9.2
T_2	20.5	5.8	410.6	133.2	12.6
T_3	21.8	6.0	440.2	105.6	13.8
T_4	22.6	6.4	471.3	94.2	15.3
CD(P=0.05)	3.18	1.58	12.86	13.98	1.23

Sunflower is one of the most sensitive crop to low boron supply and boron deficiency has been observed around the world in sunflower cropping (Blamey, 1976). Oyinlola (2007) and Shekhargouda *et al.* (2006) reported that boron is essential to sunflower plant during reproductive stage rather than in vegetative stage. Boron deficiency symptoms usually appear as stem cracks, deformed capitulum, poor seed set and lower seed yield (Zhang *et al.,* 1994 and Dell and Longbin, 1997). Nanja Reddy

et al. (2003) also reported that boron played a major role in membrane integrity, cell wall development and helps in pollen tube growth, thereby increases the seed yield. The results from Table 3 showed that adding 10q/ha of borax as soil application, the yield of T_4 increased by 1.5q/ha more than in T_3. Thus, it could be concluded that boron, as an essential nutrient plays a vital role in increasing sunflower productivity. There was a yield gap of 3.4 q/ha in application of recommended dose of fertiliser (60: 80: 60 kg NPK/ha) with farmer's practice. Similarly PMS @ 5q/ha and gypsum application @ 2.5 q/ha also gave an additional productivity of 1.2 q/ha over the T_2. Similar observations were recorded from the studies of Bhagat *et al.* (2005) who reported that seed yield increased significantly on application of sulpher based fertiliser like gypsum. There found no significant difference in capitulum diameter among T_2, T_3, T_4. But, a visible advantage of the additional inputs on the number of filled seeds and yield was noticed in these three treatments. The findings of Ram and Davari (2011) support the above study. Application of RDF, PMS, gypsum and boron (T_4) in recommended doses gave an additional yield of 66.3 per cent over the farmer's practice. The economics of all the treatments and replications were calculated and analysed. The following figure depicts the comparison between the cost of cultivation of FP (T_1) and the most effective treatment (T_4).

Table 3 : Economics of the treatments in farmers' field (Average of two years)

Treatments	Cost of cultivation (Rs.)/ha	Gross return (Rs.)/ha	Net return (Rs.)/ha	BC ratio
T_1	9700	23000	13300	2.37
T_2	12050	31500	19450	2.61
T_3	12510	34500	21990	2.75
T_4	12960	38250	25290	2.95

Analysis of the economics of the treatments showed that addition of different inputs with T_1 increased cost of production as well as the net return. The cost benefit ratio increased from 2.37 (T_1) to 2.95 (T_4). An Investment of ₹ 3260 extra in management practices over FP, gave ₹ 11990 net return per hectare (T_4). Application of recommended dose of fertiliser, 60:80:60 NPK kg/ha + 5 tn FYM/ha + 50%N as top dressing (TD) (T_2) gave an increase of 36.95 percent yield over FP enhancing the net return of ₹ 6150 per ha. The study corroborates the findings of Vivek and Chakar (1992) who reported that in sunflower crop higher dose of fertiliser application resulted in a significant increase in seed yield. Since the critical inputs like PMS for reducing acidity, gypsum for increasing oil quantity and boron

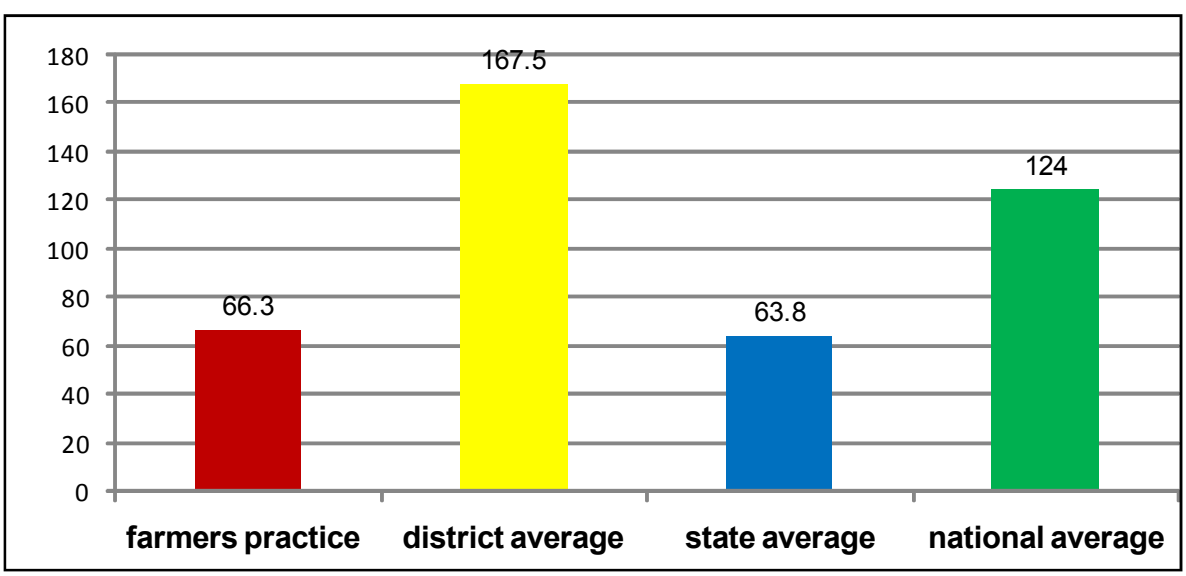

Fig. 1 : Yield advantage (%) of the recommended practice(T_4) over other parameters

Fig. 2 : Farmers' Practice (T1)

Fig. 3 : Top dressing of fertiliser

Fig. 4 : Vegetative stage

Fig. 5 : Pre-flowering stage(50 DAS)

Fig. 6 : Seed setting stage

Fig. 7 : Growth parameter of capitulum

for increasing productivity are provided by the agriculture department at subsidised cost, the application of them certainly has a positive impact towards the productivity of sunflower crop in this plateau ecosystem. The yield of recommended practice following the best nutrient management module (T_4) were compared with the farmer's practice, district, state and national averages (Odisha agricultural statistics, 2008-09) and was found giving higher yield of 66.3%, 167.5%, 63.8% and 124.0% respectively (Fig. 1).

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IMMUNE RESPONSE IN CALVES FED ON LOW GRAIN AND GRAIN LESS CALF STARTERS

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ABSTRACT

Twenty-four calves after colostrum feeding (3 days) were randomly distributed in three groups of 8 calves each (*Bos indicus x Bos taurus*) and a feeding trial was conducted for 156 days to assess the immunocompetency of calves. Three iso-nitrogenous calf mixture containing 0, 25% and 50 % cereal grain (maize) were fed from 2nd week onwards on a green berseem (*Trifolium alexandrimun*) based diet. A standard milk feeding schedule of 9 weeks duration was followed for calves in all the groups. Dry matter intake, body weight gain and feed conversion efficiency were similar in all the groups. Both humoral and cell mediated immune response assessed after the feeding trial did not show any significant ($P<0.05$) intergroup variation in response to dietary treatments. The results indicated that energy rich grain can be replaced partially or by a suitable cereal grain byproduct of low energy value in the concentrate mixture of neonatal calves without any adverse effect on body immune system.

Key words : Crossbred calves, cereal grain, energy, immunocompetency

INTRODUCTION

The scope of utilization of cereal grain as feed ingredient in cattle ration seems to be worse in India and other developing countries. It may be difficult to use substantial amount of cereal grains in calf starter for the feeding of growing ruminants. Thus, there is a need of developing a feeding strategy based on cereal grain byproducts with green fodder for young ruminants. However, calf rearing with replacement of energy dense cereal grain with their byproducts may expose the young ruminants to energy deficiency, if there is no adequate feed intake. Energy deficient diet may adversely affect immunocompetency of young growing animals due to marked reduction in immunoglobulin synthesis (Griebel *et al*., 1987). Nutritional deficiency has been observed to have diverse immunological effects including decreased cell mediated immunity-cell numbers, helper T-cell function and complement activity (Purtilo and conner, 1975; Renshaw and Everson, 1980 and Chandra *et al*., 1982).

The study was thus carried out to assess the growth performance and immunocompetency of young crossbred calves on a diet where energy rich grain was replaced with low energy grain byproducts.

MATERIALS AND METHODS

Animals and experimental feeding

Twenty four female crossbred (*Bos taurus x Bos indicus*) calves after three days of colostrum feeding were randomly allotted to 3 equal groups of similar body weight. All the calves were housed individually in well ventilated, clean and dry pens. Each calf was fed whole milk up to 9 weeks of age as per the schedule (Table 1). Clean drinking water was made available to calves, throughout the experimental period. The groups were referred as control (C), grainless (G1) and low grain (G2), based on different dietary treatments. The composition of different calf starters are presented in Table 2. Initially, during second week, calf starter was offered with milk in the form of gruel and then in the dry form. Green berseem was offered as libitum to increase the appetite. Dry matter intake (DMI) of milk, concentrate and green fodder were recorded daily. Weekly change in live weight was recorded in the morning before feeding and watering.

Blood collection

After 126 days of experimental feeding, 5 animals from each group were inoculated with HS oil adjuvant

vaccine with *Pasteurella multocida* P-52 strain. Blood samples were collected by jugular venipuncture on 0, 10, 20 and 30th day post vaccination for detection of immune response in animals.

Immunological test/ analysis

For cell mediated immune response Leukocyte migration inhibition test (LIMIT) was done by capillary tube method as per Boyuum (1968). The per cent migration inhibition was calculated by using the formula :

$$\text{Per cent MI} = \left[1 - \frac{\text{Migration in presence of antigen}}{\text{Migration in absence of antigen}}\right] \times 100$$

Standard tube agglutination test (STAT) was done according to Dua and Panduranga Rao (1978). To undertake the test, a ready made ELISA kit (Kirkegaad and perry Laboratory, Maryland, USA) was used for detecting antibody titre. The ELISA titre was calculated by application of the positive/negative ratio method of analysis.

The titre was calculated as per the formula :

Log 10 titre = (1.464 x log 10 sp) ±3.197

Titre = Antilog of 10 titre, Where

$$\text{Sp} = \frac{\text{Sample absorbed} - \text{average negative control absorbed}}{\text{Corrected positive control absorbed}}$$

Feed analysis

The chemical composition of feed was determined following the standard procedures (Anon, 1990).

Statistical analysis

Data were compiled and statistically analysed as described by Steel and Torris (1980). The difference between the treatment mean was tested by Duncan's multiple range test (Duncan, 1955).

RESULTS AND DISCUSSION

Live weight change and dry matter intake

Daily feed intake and body weight grain are presented in Table 3. There was no significant difference (P > 0.05) in body weight gain, DMI, per cent DMI, DMI per kg metabolic body size and feed efficiency amongst the groups. However, there appears to be slightly higher DMI in grain replaced groups compared to control. The concentrate to roughage ratio showed apparently increased consumption of calf starter in low grain and grainless calf starter fed groups.

Immune response

Cell mediated immunity (CMI)

The cell mediated immune response as assessed by Leukocyte migration inhibition test (LMIT) revealed similar (P > 0.05) migration inhibition (MI) at all stages (0, 10, 20 and 30th day) of test in different groups (Table 4). In all the above groups no migration was observed in the prevaccinated sera (0 day) while it reached maximum on 20th day of post vaccination. However, there was no significant difference in LMIT response between the groups.

Humoral immunity

The mean antibody titre in different groups at different intervals are presented in Fig. 1. The antibody levels at prevaccination (0 day) was not detected by STAT, but was indicated by ELISA. The antibody levels detected in both the tests started rising from 10th day of post-vaccination and reached maximum level on 20th day. However, in all the stages, the titre did not vary significantly (P > 0.05) among the groups showing no adverse effect of grain replacement on disease resistance of crossbred calves.

A relatively increased consumption of low grain and grainless concentrate compared to control may be considered as an adaptive mechanism to compensate the energy deficit. Further, replacement of energy rich maize with low energy wheat bran in the concentrate mixture of young crossbred calves did not show any significant adverse effect on live weight gain and feed conversion efficiency. A slight increase in DMI with similar body weight gain was reflected on the feed conversion efficiency of animals. Early adoption of calves to more fibrous feeds (bran based concentrate) would have established a micro-reticulum; thus promoting fibre utilization and the animals compensated the energy demand through increased intake and utilization. Lyford (1988) emphasized early establishment of rumen microflora in response to adoption of young calves to high fibrous diets replacing maize with either deoiled rice bran or soy hulls. Malik *et al.* (1989) and Faulkner *et al.* (1994) also reported similar growth performance in young growing calves. The

Table 1 (a) : Feeding schedule of calves

Age of calf	Colostrum	Whole Milk	Calf Starter	Green Fodder
0-3 days	1/10th BW	-	-	-
4-7 days	-	1/10th BW	-	-
8-42 days	-	1/10th BW	ad lib	ad lib
43-56 days	-	1/10th BW	ad lib	ad lib
57-63 days	-	1/20th BW to nil	ad lib	ad lib

Table 1(b) : Composition of calf starter

	C	G_0	G_1
Physical Composition (%)			
Crushed maize	50	-	25
Deoiled groundnut cake	30	22	25
Wheat bran	10	68	40
Fish meal	7	7	7
Mineral Mixture	2	2	2
Common salt	1	1	1
Chemical composition Diets			
DCP (%)	15.01±0.14	14.43±0.16	15.00±0.22
TDN (%)	68.55±0.29	67.15±0.58	68.37±0.58

fibre content of the diet appears to have a major role in the development of rumen function (Lyford and Huber, 1988).

The cell mediated immune response as assessed by LMIT attained as usual highest inhibition on 20th day of post vaccination (Verma and Jaiswal, 1997). The non-significant difference between the treatment groups was quite obvious as the animals did not show energy deficiency on the feeding of grain less diets and they all performed in a similar way. The antibody titre as detected by STAT and ELISA, showed steady rise up to 20th day of post vaccination

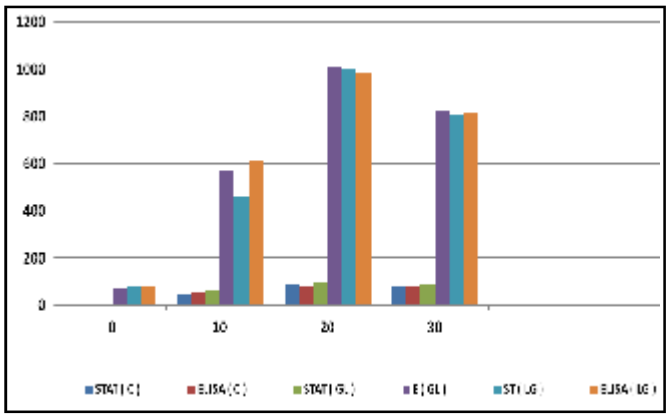

Fig. 1 : Antibody titre level in the serum of calves

and then declined as detected on 30th day post vaccination. Similar antibody titres at different post vaccination period were also detected (Pati *et al.*, 1996). As assessed, although ELISA was more sensitive to STAT in detecting antibody titre, there was nonsignificant difference between the groups.

All the above studies revealed that low grain and grain-less diet could not produce any significant immuno-suppression at any stages which was in support to their performances with regard to DMI and live weight gain reducing the energy intake by reducing the level of concentrate mixture in the diet Santra and Pathak (2000) did not observe adverse immunological response; although body weight gain was significantly reduced in experimental groups as compared to control group. In the same line,. Lebengarts (1986) also reported nonsignificant effect on immunity in heifers on a low concentrate diet. However, energy deficiency in diet has been shown to have adverse effect on immune system of man and animals (Chandra *et al.*, 1973 and Oetzel *et al.*, 1988). It has been seen malnutrition animals are more susceptible to bacterial diseases (Fiske and Adams,

Table 2 : Feed intake growth response by experimental calves

Attributes	Groups		
	C	G_0	G_1
No.of experimental animals	8	8	8
Duration of experiment (d)	156	156	156
Initial body eight (kg)	23.25	23.44	23.25
Final body wt(kg)	71.56	74.44	75.81
Average daily gain(g/d)	386.26	407.15	417.21
Average DMI(kg)	1.21	1.33	1.32
DMI(kg)/100 kg BW	2.49	2.70	2.57
DMI(g)/$W^{0.75}$kg	84.7	92.6	92.9
Concentrate :roughage	1.08	1.16	1.26
Feed conversion efficiency (DMI kg/kg gain)	3.17	3.32	3.20
Total grain spared (kg)	0.00	83.8	41.6

Table 3 : Mean per cent leukocyte migration inhibition (MI)in different groups of calves

Group	Using pooled blood sample Mean per cent migration inhibition Days post vaccination			
	0	10	20	30
1 (control)	0.00	11.25	26.75	23.50
2 (Grainless/G_0)	0.00	10.75	26.25	21.75
3 (low grain/g_1)	0.00	11.50	27.25	22.25

1985 and Griebel *et al.,* 1987). In the present study, grain replacement from the concentrate mixture with wheat bran could not impart more reduction in energy consumption. This was because the animals under the experimental groups consumed slightly higher DMI and better feed utilisation compared to control met energy demand well. Additionally, the green berseem along with bran provided a conditioned environment in the rumen to withstand the deficit as expected in low energy bran--based groups. The results of DML live weight gain and cellular and humoral immunity were thus comparable and envisaged enough scope to spare cereal grains for the feeding of human beings and monogastrics keeping in view production optima constant.

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EFFECT OF VARIOUS GENETIC AND NON-GENETIC FACTORS ON LINEAR TYPE TRAITS IN SAHIWAL CATTLE

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ABSTRACT

The expression of linear type traits are known to be affected by various genetic and non-genetic factors. Thus, for present investigation, effect of such factors on 17 linear type traits *viz*. stature (ST), chest width (CW), body depth (BD), rump angle (RA), rump width (RW), rear leg set-side view (RLS), rear leg set-rear view (RLR), foot angle (FA), udder depth (UD), rear udder height (RUH), udder balance (UB), udder cleft (UC), fore udder attachment (FUA), teat length (TL), fore teat placement (FTP), rear teat placement (RTP) and teat thickness (TT) were evaluated. The present investigation revealed that heritability estimates of only five traits viz. ST (0.44 ± 0.48), CW (0.36 ± 0.46), BD (0.40 ± 0.48), RW (0.44 ± 0.43) and FA (0.71 ± 0.55) was higher. The correlations between most of the traits was low to moderate, however, some significant correlations was also observed (ST-BD/TL, CW-BD, BD-TL, FA-RUH, UB-TL, TL-TT, BD-UD, RLS-FA, FA-UC, RUH-RTP, UB-RTP, BD-RLS/R, BD-UC, RUH-TL, RUH-UC and FTP-UB). The different non-genetic factor exerts varying significant effect on expression of linear type traits (Age on ST, BD, UC; Parity on ST, TL BD; Farm on RLR, UD, TT, CW, BD, FUA, TT; Sire on TL). These estimates may be useful in multiple-trait animal evaluation and in studying selection responses in multiple traits.

Keywords : Linear type traits, selection responses, genetic and non-genetic factors

INTRODUCTION

The linear type traits describe biological extremes for a range of visual characteristics of an animal (Berry *et al*., 2004). These traits have been used as indirect selection criteria for improving the herd life of dairy cows (Cruickshank *et al*., 2002), but the expressions of body traits are known to be affected by various genetic factors such as heritability and correlation (Toghiani, 2011) and non genetic factors such as age, parity, farm and sire (Parveen, 2008). Thus, the present study was conducted to determine the effect of such genetic and non-genetic factors on linear type traits in Sahiwal cattle.

MATERIALS AND METHODS

For present investigation, 101 Sahiwal cows available at Bull mother experimental farm (Farm no. 01) and Cattle breeding farm (Farm no. 02) located at the premises of veterinary college, Anjora, Durg (Chhattisgarh state) were selected randomly to measure 17 linear type traits *viz*. stature (ST), chest width (CW), body depth (BD), rump angle (RA), rump width (RW), rear leg set-side view (RLS), rear leg set-rear view (RLR), foot angle (FA), udder depth (UD), rear udder height (RUH), udder balance (UB), udder cleft (UC), fore udder attachment (FUA), teat length (TL), fore teat placement (FTP), rear teat placement (RTP) and teat thickness (TT). All the selected animals were classified on the basis of their age, parity, farm and sire. Prior to estimation of heritability estimates, the data were adjusted for different significant non-genetic factors (season, period, age, parity, farm and sire). The least squares analysis of variance was carried out using the technique as described by Harvey (1966). For determining the heritability estimates of different linear type traits, paternal half sib correlation (intra-sire correlation among daughters) was used. The correlation co-efficient among each linear trait were calculated by using formula as given by Snedecor and Cochran (1989). To study the effect of age, parity, farm and sire on various linear type traits, analysis of variance with one way classification were applied as per the method described above.

RESULTS AND DISCUSSION

Effect of genetic factors on linear type traits

Heritability estimates of linear type traits were determined in Sahiwal cows ranged from 0.014 to 0.713 i.e. low to high *a*s shown in Table-1. However, heritability of few traits such as RA, RLR, UB and UC could not be determined.

The low heritability estimates was observed for traits such as RLS (0.02±0.37), UD (0.11±0.38), RUH (0.03±0.37), FUA (0.01±0.35) and TT (0.02±0.35). Similar results were reported by Norman *et al.* (1988) and Thompson *et al.* (1981) in Ayrshire and Holstein breed of cattle respectively. The low estimate of heritability for these traits indicated that most of the variations of these traits are non-genetic in nature and the influence of such traits can be improved by improving the management practices.

The heritability estimates was found to be moderate for traits such as TL (0.26±0.41), FTP (0.29±0.44) and RTP (0.20±0.40). Similar results were reported by Berry *et al*. (2004) in Holstein-Friesian cattle. The moderate heritability indicates that the variations in these traits are genetic in nature however, the selection program focused on improvement these traits will takes much longer duration of time.

The high heritability was observed in ST (0.44±0.48), CW (0.36±0.46), BD (0.40±0.48), RW (0.44±0.43) and FA (0.71±0.55). With the exception of foot angle, rest of the traits was well within range as reported by various earlier workers in different breeds of cattle. Moreover, Berry *et al.* (2004) had also observed similar results in Holstein-Friesian cattle. The higher estimates of heritability obtained in the present study indicated that this trait was more influenced by genetic factors and had better scope for genetic improvement through selection.

The correlation among different linear type traits ranged from -0.64 (BD and RA) to 0.38 (CW and BD). Thus, with the exception of correlation between BD and RA (-0.64), rest of the correlations were low to moderate. Moreover, most of the correlations were almost null and non-significant. Positive correlation indicates that selection for increasing score in one trait will be accompanied by increasing scores in the correlated trait and vice-versa for negatively correlated traits.

The body conformational traits such as ST and BD had shown significant and favorable correlations with udder related traits such as udder cleft (0.21* and 0.25* respectively), udder depth (-0.36** and -0.31** respectively) and teat length (-0.37** and -0.28** respectively), which means that taller and stronger cows will have will have a stronger suspensory ligament of udder cleft, shorter teats and the udder will have a proper distance from the hock. Consequently, mastitis suffering probability will be low for these cows, which was in accordance with Berry *et al.* (2004). However, Togihani (2011) in Holstein-Friesian breed had observed less probability for mastitis in bigger and thinner cows.

The significantly favorable correlation exists between ST and BD (0.30**), CW and BD (0.38**). The BD in turn had shown significantly positive correlation with RLS (0.29*) and RLR (0.25*), which indicates that taller cows possess much wider CW and stronger BD with their legs tended to be more sickle. Such legs might be an adaptation of an animal to bear the weight of tall and stronger body.

The significantly unfavorable correlations were observed between FA with RLS (-0.32**), UC (-0.28**) and RUH (0.29**), which indicates that cows with stronger, shallower udders will have more sickle legs and lower foot angles. Moreover, Berry *et al.* (2004) had also observed similar findings in Holstein-Friesian cattle.

TL and TT had shown significantly favorable correlation (0.27**) with each other, which indicates that increase in TL leads to corresponding increase in TT. Since ST is negatively correlated with TL. Thus, it can be supposed that taller animals will have shorter and narrower teats. This may have practical implications for efficient milking, especially with robotic milking systems.

Effect of Non-genetic factors on linear type traits

Effect of age

The effect of age was significant (P < 0.05) on ST, while the same effect was found to be significant (P < 0.01) on BD and UC. Rest of the traits had shown non-significant effect. As the age advances, there was significant growth in these respective traits as compared to other traits.

Effect of Parity

The effect of parity was significant (P < 0.05) on ST and TL while the same effect was significant (P < 0.01) on BD. Moreover, Parveen (2008) and Yanar *et al*. (2000) had also observed similar effect of parity on different body measurements in Sahiwal and Brown Swiss cattle respectively.

Effect of Farm

The effect of farm was significant (P < 0.05) on RLR, RUH, TL and TT while the effect of same was significant (P < 0.01) on CW, BD, FUA and FTP. The possible reason for such significant influence is due to prevalence of different management and nutritional practices on different farms, thus affecting the expression of conformation traits. This finding was in accordance with Parveen (2008) where she had observed significant influence of farm on different body measurements in Sahiwal cattle.

Effect of Sire

The effect of sire was significant (P < 0.05) only on TL while rest of the traits showed non-significant effect. The significant effect of sire on TL indicates the existence of genetic variation in teat length which suggests that this trait can be improved by implementing proper selection program of animal. Arango *et al*. (2002) had also observed the significant effect of sire on different body measurements in different breeds of cattle such as Angus, Brahman, Hereford, Sahiwal and Tarentaise.

CONCLUSION

The present investigation revealed that heritability estimates of only five traits viz. stature, chest width, body depth, rump width and foot angle was higher. The correlations between most of the traits were low to moderate however, some significant correlations were also observed. The magnitude of heritability for linear type traits, combined with correlations between traits, gives an indication of the rate of change expected in body conformation when selection is performed on these traits. The different non-genetic factor exerts varying significant effect on expression of different linear type traits. Thus, information provided in this study could be used to create specific selection indices that would reflect the optimal conformation of dairy cows in each region in terms of functional longevity. Moreover, these estimates should be useful in multiple- trait animal evaluation and in studying selection responses in multiple traits.

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STUDY ON CHANGES IN SOIL STATUS AT DIFFERENT AGES OF EUCALYPTUS MONOCULTURES OF G. UDAYAGIRI FOREST, ODISHA

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ABSTRACT

The soil of G. Udayagiri forest is red in colour with high pH and poor in nutrient status. The change in soil nutrient status was studied under 5, 10, 15 and 20 years old eucalyptus monocultures, in comparison to natural sal forest. Soil nutrient depletion under 10 and 15 years old monocultures were higher than 5 and 20 years old monocultures, in comparison to natural sal. Soil profile attributes showed gain in clay content and available P and loss in total K and P in all monocultures as compared to natural sal. The soil under 5 and 20 year monocultures were less depleted because of faster mineralization of residual organic matter in 5 years old monoculture and gradation of soil nutrient as the monoculture aged as in 20 years old monoculture.

Key Words : Soil nutrient, sal, eucalyptus, monoculture

INTRODUCTION

The wide gaps between demand and supply of timber, fuel and fodder have led to the monocultures in which human intervention has a strong role to play. However, the nutrient management in monocultures is either negligible or based on the assumption in infinite capacity of soil to maintain the stand or replenish the enormous nutrient export from the land after energy rotation. This is not so as amply born out by the recent findings on the soil depletion and unfavourable nutrient changes in intensively managed tree monocultures. The documented report on eucalyptus with respect to nutrient changes bring the fact to light. Proper understanding of soil : plant relationship can put this view on a traditional basis and lead to more scientific approach to management of monoculture of tree species. It is extremely important to develop forest fertility evaluation programme in order to assess soil fertility, nutrient depletion rate due to plantation of different species. (Balamurungan, 2000; Bhowmik *et al.*, 2003 and Laclau, *et al.*, 2010).

The present paper is an attempt to provide the rate of nutrient depletion or gain in the soil due to eucalyptus monoculture of different ages in comparison to natural forest.

MATERIALS AND METHODS

The studies were undertaken in G.Udayagiri forest of Odisha situated at 20° 08' - 20° 13' N latitude and 84° 23' - 84° 38' E longitude from August 2009 to July 2011. The soil of the area is red laterite with high pH and poor to moderate nutrient status. Some of the areas remain waterlogged during monsoon. The temperature ranges from 5^0 C in December to 44.3^0 C in May. Monoculture of eucalyptus plantations of 5, 10, 15 and 20 years were selected for study along with adjoining sal natural stand of *Shorea robusta*. Nine sites under each plantation were selected and the soil samples from each location were collected through auger boring from 0- 5, 15-30, 30- 60, 60- 90, 90-120 and 120-180 cm depths. Soil samples were air dried and processed as per the standard procedures described by Jackson (1967). Physical and chemical properties were determined by standard procedures described by Black (1965) and Piper (1966).

RESULTS AND DISCUSSION

Analytical results of physico – chemical attributes of soils under different monocultures and natural Sal are given in Table 1. Soil under natural sal is considered as the benchmark soil to compare the magnitude of change in soil properties.

Table 1 : Physico-chemical attributes of soil under natural sal and eucalyptus monocultures of different ages

Species	Depth	Texture	Clay%	Org.C	pH	Nutrient Content(in mg) Total			Exchangeable Available			Ca++	K+
						N	P	K	N	P	K	(%)	(%)
	(cm)	Class		g/kg			(P_2O_5)	(K_2O)		(P_2O_5)	(K_2O)	(m.e.)	
Natural	0-15	Cl	20.3	18.3	6.3	1.2	1.2	6.6	0.11	0.02	0.27	6.5	0.32
Sal	15-30	L	20.1	8.7	5.8	0.6	1.3	5.7	0.07	0.01	0.22	3.8	0.32
	30-60	Cl	21.6	3.8	5.7	0.5	0.7	7.7	0.06	0.01	0.2	2.9	0.40
	60-120	L	21.4	2.7	5.8	0.4	0.8	5.3	0.04	0.01	0.18	2.5	0.30
	120-180	L	22.3	1.9	5.4	0.3	0. 6	5.5	0.04	0.01	0.19	2.3	0.26
W. mean			21.55	4.38	5.69	0.47	0.80	5.89	0.05	0.01	0.20	2.94	0.31
Eucalyptus	0-15	L	21.3	18.2	6.1	1.2	0.9	3.0	0.10	0.04	0.39	2.72	0.89
5 years	15-30	L	20.2	10.4	6.0	1.0	0.8	3.8	0.02	0.04	0.31	2.76	0.88
	30-60	L	22.2	7.4	6.0	0.6	0.7	3.6	0.05	0.05	0.35	2.68	0.91
	60-120	L	25.3	5.0	5.0	0.4	0.7	3.7	0.05	0.03	0.33	2.68	0.83
	120-180	L	24.8	2.2	5.7	0.3	0. 7	3.4	0.04	0.04	0.38	2.84	0.75
W. mean			23.96	6.02	5.58	0.52	0.73	3.53	0.05	0.04	0.35	2.74	0.83
Eucalyptus	0-15	L	22.7	13.3	6.3	1.2	0.19	4.1	0.10	0.01	0.50	2.60	0.26
10 years	15-30	Cl	24.7	12.9	5.7	0.7	0.60	3.4	0.06	0.01	0.51	2.0	0.28
	30-60	Cl	27.1	1.8	5.8	0.4	0.97	3.1	0.05	0.01	0.47	1.6	0.28
	60-120	Cl	28.5	2.7	5.7	0.4	0.05	3.6	0.04	0.01	0.39	1.6	0.26
	120-180	L	23.8	2.6	6.0	0.2	0.04	3.8	0.03	0.01	0.36	1.6	0.28
W. mean			24.51	4.23	5.87	0.43	0.26	3.61	0.05	0.01	0.41	1.72	0.27
Eucalyptus	0-15	L	21.1	9.1	6.0	1.1	0.3	3.7	0.12	0.07	0.32	2.3	0.32
15 years	15-30	Cl	22.8	5.7	6.2	0.5	0.3	3.7	0.07	0.07	0.13	1.8	0.26
	30-60	Cl	25.7	2.5	5.8	0.4	0.4	5.1	0.05	0.06	0.14	1.7	0.70
	60-120	L	25.9	1.4	6.1	0.4	0.3	4.0	0.04	0.06	0.12	1.5	0.23
	120-180	Cl	22.6	1.3	6.0	0.2	0.3	4.6	0.03	0.06	0.10	1.8	0.22
W. mean			24.13	2.53	6.0	0.38	0.30	4.34	0.05	0.06	0.13	1.72	0.32
Eucalyptus	0-15	L	19.4	14.8	6.0	1.1	0.5	7.7	0.12	0.07	0.16	4.3	0.44
20 years	15-30	L	19.6	6.5	5.9	0.7	0.5	8.2	0.09	0.04	0.15	2.7	0.41
	30-60	L	21.2	3.5	5.7	0.5	0.5	7.8	0.08	0.05	0.14	2.7	0.33
	60-120	L	28.6	2.1	5.9	0.4	0.4	8.8	0.06	0.06	0.10	2.5	0.29
	120-180	L	27.4	2.2	5.7	0.5	0. 3	6.5	0.06	0.03	0.14	2.9	0.34
W. mean			25.48	3.78	5.79	0.51	0.40	7.73	0.07	0.05	0.13	2.80	0.39

Cl = Clay loam, L = Loam

Results showed pronounced migration of clay particles down the soil profile in 5 years monoculture than natural sal. Organic carbon, total and available nitrogen, available phosphorus, potassium content were higher in 5 years monoculture than in natural sal. This trend could be due to enhanced micro-biological activities in freshly exposed sites. It was observed that after cleaning an area for reforestation and due to exposure the of sun light, soil moisture and temperature increased promoting rapid decomposition of organic matter; hence available nutrients and humus increased during this period. A five year monitoring of eucalyptus plantation showed variable increase in organic carbon and soil phosphorus (Kushalappa, 1985). Jha and Pandey(1984) have also reported that eucalyptus monoculture of fairly young age indicated higher accumulation of organic matter in comparison to sal monoculture. Soils under 10 years eucalyptus monoculture were less acidic compared to natural sal. Migration of fine particles down to the soil profile were clearly observed only upto 120cm depth. Enrichment of organic carbon , total N,P,K available, exchangeable Ca^{++} and K^{+} were less in the soils under 10 years old eucalyptus monoculture than natural sal. All the nutrients except total and available K were found less in the soils under 10 years monoculture than 5 years old monoculture. This may be because of higher uptake of nutrients by well developed vegetation in comparison to 5 years old eucalyptus as well as low residual nutrient pool from clearing. Migration of fine particles down the soil

profiles were clearly observed in the soils under 15 years old eucalyptus monoculture but this migration was less marked as compared to 10 years old plantations. After early duration of time i.e., under 5 year old plantation, migration of finer particles started but it was pronounced in 10 years old plantation. There after, this process became slower under 15 years old plantation and upto certain age i.e., 20 years. In this case these processes became stabilized and rapid migration checked especially in upper layers. Soils were less acidic in reaction below 15 cm depth under15 years old monoculture in comparison to not only with natural sal but also 5-10 years old monocultures. Soil under 20 years old monoculture were also acidic. In general organic carbon, total P, available K, exchangeable Ca, were less in all depths in soils under 20 years old monocultures while total N, K and available N and P the trend was reversed. Nutrient status of soil under 5, 10 and 15 years old eucalyptus monoculture were generally in decreasing order. Thus, it is observed that soil enriches due to the rapid decomposing of litter after clearing. The higher fertility condition is not maintained because of absence of further leaf fall.

Different soil analysis of 5, 10, 15 and 20 years old eucalyptus monocultures enabled us to compare the soil attributes under eucalyptus monoculture and natural sal. It was also tested whether these monocultures of different duration had any effect on soil attributes at different depths. The observations were made at 0- 30, 30- 60 and 60- 120 cm. depths and were described as top, middle, and lower layers with regard to rooting activities. Data are shown in Table 2.

The observations on the total N content(Nitrate) in different depths under 5 years old plantation showed a gain of 20-22 per cent in upper and middle layer and no change in lower layer. There was a decrease in total K level of nearly half in top and middle layer and about 29 per cent in lower layer. The available P under 5 years old plantation showed phosphorus build up of 1.6 times in top, 4 times in middle and 2 times in lower layer. The soil phosphorus changes are at variance with others primarily due to microbial link with its content, species requirements and appropriateness of phosphorus extraction method. There was a gain in available K of 45 per cent in top, 75 per cent in middle and 83 per cent in lower layers. Yadav *et al.* (1973) have also reported slightly decrease in HCl soluble K_2O and P_2O_5 and increase in the availability of K_2O in the soils during 5 years under eucalyptus monoculture in comparison to natural sal. There was a general gain in clay content in top and lower layers while a marginal loss of 2 per cent in middle layer. Downward movement in finer particles in the soil under 5 years old monoculture is in confirmity with the findings of Yadav *et al.* (1973).

In the soils under 10 years old eucalyptus monoculture, there was no change in contents of total nitrogen in upper and lower layers where as contents decreased by 29 per cent in middle layer. Total phosphorus showed accumulation of 8-12 per cent in top and middle and loss of about 37 per cent in lower layer. There was a loss of total potassium about 40 per cent from the top, 58 per cent from the middle and 30 per cent from the lower layer. Available nitrogen content under 10 years old monoculture

Table 2 : Loss and gain in soil attributes down the profile under different monoculture plantations in comparison to natural sal

Species	Depth (cm.)	Clay	D.C.	Total Nutrients(in mg)			Available Nutrients		
				N	P	K	N	P	K
Eucalyptus	30	2	6	22	-33	-45	0	167	46
5years	60	-2	85	20	-13	-52	-17	400	75
	120	22	100	0	-13	-29	25	200	83
Eucalyptus	30	28	-3	0	-8	-40	-11	-33	108
10 years	60	32	55	-20	13	-59	-17	0	135
	120	29	4	0	-38	-31	0	0	116
Eucalyptus	30	20	- 45	-11	-75	-42	-11	367	-8
15 years	60	23	-35	-20	-38	-31	-17	500	-30
	120	35	-44	-25	-63	-19	0	500	0
Eucalyptus	30	7	-21	20	-42	27	11	366	-37
20 years	60	2	-10	20	-38	4	33	300	-30
	120	51	-20	20	-50	69	50	400	-44

showed loss of 11 per cent from top, 17 per cent from middle and lower layer remains unchanged.There was a gain in potassium content of 1.08 times in top, 1.35 times in middle and 1.16 time in lower layer.

Under 15 years old monocultures, there was loss of soil nitrogen by 11 per cent in top and 20- 25 per cent from middle and lower layers. The changes in soil nitrogen showed an increase in content in the short term followed by a fall when the longer duration plantation were tested, as in case of organic carbon.

A substantial loss of total phosphorus 75 per cent from top, 37 per cent from middle and 62 per cent from the lower layers in 15 years plantation was observed. Loss of 42 per cent from the top, 30 per cent from middle and 19 per cent from the lower layer was observed in total potassium contents. Available nitrogen contents followed the same trend as under 10 years plantation. The available phosphorus content under 15 years old monoculture showed a build up of 3.66 times in top, 5 times in middle and lower layers. Nutrient removal in a short rotation of eucalyptus plantation is dependent upon the species, and the harvesting regime (Wise and Pitman, 1981).

Organic carbon content under 20 years old eucalyptus monoculture plantation showed a little recovery in comparison to 15 years plantation but ultimately showed loss of 21 per cent in top, 10 per cent in middle and 20 per cent in lower layer in comparison to natural sal. Total nitrogen content was same as under natural sal. There was loss in total P and available K contents in all depths while gain in total K , available N and P and clay content in all depths in comparison to natural sal. Gain in clay content, total K, available N and depletion in organic carbon, total P and available K in the soils of 17 years old eucalyptus monoculture in comparison to natural sal was reported by Jha and Pandey(1984). It was evident from the data that soils under 20 years old plantation were not so much depleted in nutrient in comparison to 10-15 years old plantation. It also corroborates with the work undertaken by O'Connell, *et al.*(2004) which states that soil approaching 20 years eucalyptus plantation starts maintaining its fertility because of little accumulation on forest floor and consequent mineralization process yielding nutrient demands of the root surface.

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VULTURE MORTALITY : AN ANALYSIS IN INDIAN CONTEXT

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ABSTRACT

Vultures play a very important ecological role in clearing the carcasses by rapidly consuming remains of dead animals. This process prevents the carcasses to act as host for various diseases that may spread to livestock. Despite high ecological significance of vultures, their population is severely declining or locally extinct not only in India but also in many parts of the globe. It indicates the emergency to revive their population both by laboratory and field interventions. This article is an attempt to identify the possible causes and remedies of their disappearance from the ecosystem. More investigation on health problems relating to life cycle and pathogenesis of vultures is to be performed. Research in many parts of India indicates that diclofenac contamination from infected domestic carcasses is attributed for vulture death. Some of the studies also pointed about other problems in their habit and habitats, food and feeding, nesting and breeding, reproduction, environmental factors especially temperature, epidemic and endemic diseases etc., which might attribute for their death. India is ahead of taking steps for plan for recovery of vultures may be for which the rate of population decline of long-billed vulture are substantially slower being 16% per year than the catastrophic decline rates for oriental white-backed vulture 44% per year. However, reports are scanty about the susceptibility of vultures to any unique pathogens or diseases after diclofenac contamination or their exposure to any other contaminants or pollutants which push them to die. Such study would throw light on cause of vulture death to eradicate the limitation of diclofenac or any other organic and inorganic pollutants are the only cause of vulture death.

Key words : Vulture, extinction, causes, remedies, ecosystem, scavengers, diclofenac

INTRODUCTION

An ecosystem is stabilized by different trophic levels without which it is pushed to an unbalanced state. Trouble to any of the trophic organisms such as producers, consumers or scavengers, eventually not only leads to disturbances in the food chain but also it makes disorder in the existing food web (Sutherland and Green, 2004). It is noteworthy to mention here that scavengers occupy an imperative level in a food chain without which eco-maintenance of dead carcasses either stopped or delayed (Egerton, 2007). It leads to several ecological disturbances (Brinson *et al.,* 1981 and Pimm, 2002). Specifically, it is believed that their absence can lead to a remarkable crisis in terrestrial ecosystem (Verner *et al.,* 1986). The vanished vultures, an excellent scavenger of dead bodies, are in critically endangered state because of the severe declining of their population or locally extinct not only in India but also in many parts of the world (Baral *et al.,* 2005; Mandel *et al.,* 2008; Markandya *et al.,* 2008; Anon, 1986, 2007, 2012; IUCN 2012 (Fig.1). They feed mostly the carcasses of animals. They do not kill animals but by consuming the dead animals, they keep environment clean (Fig. 3 and 4). In the absence of any alternative mode of disposal of animal carcasses, these continue to be disposed of openly. It leads to increased risk of rabies and other live stock born diseases like anthrax. Therefore, the scavenging act of vultures prevents spread of dangerous diseases, which could play havoc to the wildlife, live stocks and human beings as well (Taigor, 2010)

The causes of loss of scavengers including vultures from a specific habitat are found to be multiple (Cuthbert *et al.,* 2007). Specific studies high lighted more about the persisting problems related to the

causes and consequences of vulture extinction from a habitat (Prakash, 1988, 1999, 2003; Prakash *et al.,* 2003, 2005, 2007; Arun and Azeez, 2004 and Pain *et al.,* 2008, Fig. 2). Even in protected area, they are found to exist in few numbers (13 to 65) (Taigor, 2010). The Indian white-backed (*Gyps bengalensis*) and long-billed (*Gyps indicus*) vultures were the most abundant vulture species in India before more than four decades ago (Anon, 1986; Pain *et al.,* 2008; Taigor, 2010). Unfortunately, they are now on the verge of extinction. In Indian sub-continent, the problem was scientifically documented by the Bombay Natural History Society (BNHS). In 1999, data published from a study by BNHS at Keoladeo National Park (KNP), a world heritage site, showed a 96% decline in the Indian white-backed vulture population and a 97% decline in the long-billed vulture population between 1985 and 1999 (Prakash, 1999). The same reports have also been reported by Prakash, 2003; Baral *et al.,* 2005 and Prakash *et al.,* 2007. In 2000, nation-wide surveys showed similar declines in vulture population throughout India (Rasmussen and Anderton, 2005). Afterwards similar reports have been sorted out with *Gyps* spp. population by several experts in neighboring countries such as Nepal and Pakistan (Baral *et al.,* 2004; Shultz *et al.,* 2004; Prakash *et al.,* 2007 and Pain *et al.,* 2008).

Beginning in 1985, Prakash *et al.,* worked in Rajasthan's Keoladeo National Park, where white-rumped vultures nested and long-billed vultures came to forage from nearby breeding sites. He saw the numbers of the park's white-rumps go from a peak of 1,800 in 1985-86 to only 86 in 1998-99, while long-bills fell from 816 to 25 (Prakash *et al.,* 2003, Fig. 3). Therefore, the right time of the task to discuss about the cause and remedial measures against vulture death has gone back to many decades back. Now, the problem must be taken seriously to put forward specific scientific and social strategies in order to revive their population. Many instances are there by which declining trend of a particular population has been revived with a remarkable increase in their number. Revival of Rhinoceros population in India happens to be the bright example for it. This particular problem of vulture extinction has drawn equal importance for the Government to initiate programs like COMPAS (Coastal Ocean Monitoring and Prediction System), ICMAM (Integrated Coastal Mapping and Management), BOBP (Bay of Bengal Program) etc. which were made to protect coastal ecosystem and the overall living organisms in India.

The study aims at evaluating causes and possible remedial measures against the rapid decline of vulture populations in India.

CAUSES OF VULTURE MORTALITY

Environmental forces

Environmental factors such as extreme heat or cold, chemical pollution in air and water, heavy cyclone, loss of habitats, loss of forest canopy, imbalanced food chain etc. are always detrimental factor for the disappearance of a species from the world. Such factors are enhanced by human activities and become threat to the inhabiting species. Although specific studies lack to describe environmental force as the cause of mass scale vulture destruction in India or else where, factors such as heavy cyclone were found to have important role on the declining vulture population. A personal observation made by the authors at the coastal belt of Jagatsinghpur district of Odisha state, India revealed that after super cyclone of 29th October 1999 with a cyclonic gale of 300 kmph, no vultures were visible in the coastal belt of Jagatsinghpur district, specifically in the area of Patrapada, Kakatpur, Astaranga, Kusupur, Nandhara, Olara, Padmapur, Paradeep, Belapur etc. During 1990, a severe cyclone was found to reduce the vulture population significantly at Guntur and Prakasham area of Andhra Pradesh, India (Satheesan and Satheesan, 2000). It implies that heavy cyclone may be the major factor of loss of vultures and their large nesting trees.

Pollution and other environmental factors

Many vultures are usually colonial in nature. By drinking polluted water containing either pathogenic organisms or organic/inorganic poisons, might have caused disappearance of the vultures patch wise. For example, presence of a novel Mycoplasma species (*Mycoplasma vulturii*) in tissues of oriental white-backed vulture (*Gyps bengalensis*) is reported at Changa Manga forest plantation area of Pakistan (Oaks *et al.,* 2004b). These species could be responsible for heterophilic inflammation in the trachea and bronchi of the bird causing death. Pathogens of malaria can grow better in water lodging polluted area. Though, malaria is not water borne disease, pathogens causing malaria could be

a cause for death of the wild population of the Indian white-backed vulture *Gyps bengalensis* (Poharkar *et al.,* 2009). Persistently, several organochlorine pesticide residues (p,p'-DDE, p,p'-DDT, HCH, Dieldrin etc.) detected in tissues and eggs of white-backed vulture, *Gyps bengalensis* from different locations in India such as at Delhi and Mudumali. Indian white-backed *Gyps bengalensis* and long-billed *Gyps indicus* vulture populations were also noticed to be affected with drooped neck posture followed by death due to pesticide contamination in their tissues (Prakash *et al.,* 2003). Gilbert *et al.* (2007b) recorded that neck-drooping is highly temperature specific in the above vultures which may be responsible for thermoregulation purposes. From these two studies, it will not be sufficient to conclude that neck drooping is purely temperature dependant. Perhaps, a combined observation of neck-drooping as a function of temperature and pesticide contamination will solve the above limitation since pesticide contaminations do have a relation with neck-drooping in vultures.

Due to arboreal and colonial nature of vultures (Fig. 2), environmental conditions like high rainfall, high or low temperature and cyclone might be responsible to affect their life. Irregular and unexpected weather conditions including high or low rain fall and temperature cause loss of green forest and virtually the ecological crash in general. Loss of green canopy always leads to disturb bio-geochemical cycles. Finally, disturbances in bio-geochemical cycles such as water and carbon dioxide cycles directly influence rain fall and temperature. Nitrogen cycle influences canopy growth and development. It leads to rise in environmental temperature. All the processes are found to affect avian life into a greater extent (Houston, 1985; Octavian, 1896). It is noted that neck-drooping posture followed by mortality in oriental white-backed vultures (*Gyps bengalensis*) is correlated with failure in its body thermoregulation with respect to environmental temperature (Gilbert *et al.,* 2007b). After severe declined population to almost extinct condition of vultures locally in 1990 due to a severe cyclone, the remaining few vultures again were drastically reduced there due to hunting of the vultures for meat by the Bandola (Banda) people in the districts of Guntur and Prakasham of Andhra Pradesh (Satheesan and Satheesan, 2000). Similarly, a personal record by the authors indicates that vulture population was nil at the coastal belt (especially that of costal areas of Jagatsingpur district and few places of Kendrapara and Puri district) of Odisha, India after the super cyclone blown over the region in October 1999. Such extremities may not be stopped but may be minimized with the advent of new technologies and of course by promoting large scale plantation programmes.

Infection by contaminated food

Vultures are found to feed in groups (Ruxton and Houston, 2004). It creates community destruction after feeding on the contaminated foods. Dead bodies with pathogenic or poisonous threats must be properly disposed to avoid consumption of the carcasses by vultures. Many farmers spray cattle carcasses with the pesticide such as organo-chlorine and organo-phosphorous compounds to prevent them from spreading foul odour (Muralidharan *et al.,* 2008). These pesticide contaminated carcasses eaten by the vulture has reported to be a cause of their death. Instances are there for death of hundreds of vultures in this way (Oaks *et al.,* 2003, 2004a). Like wise, in parallel to diclofenac or other contaminations, many other unknown natural and man made threatening factors may be the causes of toxicity to vultures and other scavenger birds (Ramakrishnani *et al.,* 2010). These factors must be investigated with priority in order to conserve the vulture species in India or world wide (Grubh *et al.,* 1990 and Pain *et al.,* 2008).

Food poisoning

Food poisoning may contribute to a lot for death of vultures patch wise. It may be due to natural causes like toxic fungal or bacterial growth on dead bodies or man made disposal of contaminated dead bodied. Unfortunately, no such reports are available on vultures that if any deaths are there due to fungal or bacterial infections via their food materials. Although reports about identification of other microorganisms such as Mycoplasma has been reported in oriental white backed vulture *Gyps bengalensis* (Oaks *et al.,* 2004b), a search of other microbial infection or food poisoning causative agents may have fruitful results toward vulture recovery plan.

Nesting and resting place

Many vultures are found to colonize in large trees. Invading human beings into wild animal habitats and cutting large trees for various purposes leads to

destruction of the habitats of vultures. Consequently, it pushes the inhabiting animals to be displaced by migration. Such case has already been distinctly reported (Mandel *et al.,* 2008). Shedding down large trees which is preferably and specifically used for nesting purpose by vultures, has the enough reason to be a real problem for their disappearance. According to the records of Regional Museum of Natural History, Bhubaneswar, the slender billed vultures (*Gyps tenuirostris)* were found to prefer to make their nest on large trees such as banyan, mango, bullet wood etc. at the coastal belt of Jagatsingpur district of Odisha during 1992. After the elimination of the trees, the vulture population declined severely. It indicates that when the trees are chopped off, the vultures lose their population.

Genotoxic factors

Genetic selection is the most important reason by which nature selects the most adapted organism to survive in the earth. The selection is automatic and includes both phenotypic (external bodily character) as well as genotypic (DNA structure and function and chromosomal involvements) configuration of the organism. Although studies have been performed at molecular level to identify genetic evolution of vultures (Seibold and Helbig, 1995), not even a single research has been performed to analyze the genotoxic factors that might be responsible for declining vulture's population. The identified genetic or physiologic factors in vultures may be helpful for maintenance of their better health. Because it is believed that only knowing the present health status of vultures may not be sufficient to prevent their severely declining status (Mundy *et al.,* 1992)

Nutritional problem

According to the report of BNHS, although nutritional factor can not be strong cause of vulture mortality, several reports verify the opinion and conclud differently.

Food availability

Dead bodies are the only important source of food for vultures (Gough, 1936 and Houston, 1985). The way of disposal of the dead bodies of animals such as throwing into rivers, burrial into the soil obviously leads to food scarcity in vultures. So, after a normal death, the dead bodies of animals may be disposed openly far away from the human habitat especially nearer to habitats of vultures for their consumption. With a specific strategy with follow up action for proper disposal of dead bodies openly can lead to get rid of any bad consequences including pollution (Grubh, 1973). According to BNHS, although food availability may not be a strong cause for vulture mortality, the occurrences of cannibalism in vultures raise a question on the above conclusion (Prakash, 1988 and Rana and Prakash, 2003). In nature, most of the time cannibalism occurs during food scarcity (Polis, 1981). Therefore, still specific studies are required to make scientific strategies to check whether food availability can be a cause of vulture population declining (Fig.5). The behaviour of the vultures can be studied during or prior to cannibalism or food scarcity in nature (Morris, 1935; Charles, 1937 and Houston, 1974). Although, the concept of vulture restaurants already has been started in few locations in India, it is still to be expanded to various parts of the country (Gilbert *et al.,* 2007a). It would be beneficial and safe to provide vultures with food and resting place so that they can live and reproduce and facilitate population revival.

Breeding

The declining population is always revived either by slowing down the un-natural mortality rate or by high natality (reproduction) rate followed by enhanced survivability rate. If there is problem with the former case, then the decreased mortality (death) rate may not be sufficient enough for revival of the species. In this regard, no much informations are available on the problems faced by vultures over breeding activities and their complete life cycle. Identifying such factors may be helpful to take care of the vulture reviving plan quickly in both natural and artificial breeding cases (Grubh *et al.,* 1990).Longevity and breeding success of endangered in captive birds are usually higher than in the natural condition (Stott, 1948). Induced breeding in captive condition of vultures is suggested if natural natality rate is insufficient. Although world wide including in India, such measures have been taken care off, there is no such remarkable output noticed. In India, a captive care center has been constructed at Birshikargha Wildlife Sanctuary, Pinjore. Such centers are yet to be increased in number in several parts of the country (Prakash, 2003).

Incubation

Juvenile birds are more susceptible for risk of death. Apart from induced breeding, eggs of the vultures may be collected from nature for *in vitro* incubation. Baby vultures may be released into nature with enough offence and defence by which they can survive by their own. But instances show that insufficient technology and lack of experience lead to breeding failure, therefore, requirement of both techniques and technicians have got much importance for a better planned captive breeding programme.

Epidemic and endemic diseases

Any endemic or epidemic disease must be taken care off to find the remedial measures against the identified disease. Instances of vultures suffering from Malaria have been noticed (Gupta, 2011). Cunningham *et al.* (2003) investigated 28 vulture carcases, including adults and juveniles of both species of *Gyps bengalensis* and the *Gyps indicus* in detail for any epidermal epidemic infections. Significant post-mortem findings include visceral gout, enteritis, vasculitis and gliosis. Although they were not able to identify the particular causative agent of the declines, the results of their pathological studies were mostly consistent with the pathology of avian viral aetiology. Thus, to conclude that endemic or epidemic disease could be the reasons of vultures dying in the wild due to pathogenic attacks, it needs careful field interventions on their physiology at large in different parts of the world. It is to mention herewith that species of Mallophaga are found to attack much bird population casing their death (Price and Emerson, 1966 and Tandan, 2009).

Electrocution and aircraft

Electrocution as a probable cause of vulture death has been discussed by Gupta (2011). Although, this could not be a strong cause for extinction of an avian population such as vultures, a specific study indicates that a vulture out of any disorder has died with high voltage electric wires (Gupta, 2011). The increased risks of electrocution might be due to its larger body size and larger wing span of vultures. Some other species that are threatened due to electrocution are great Indian bustard, saras crane and some species of eagles. But still a concrete report has to be produced to believe this point for a strong cause of vulture deaths despite of the report of some strange accidental cases in vultures (Greenwood, 1938). On the other hand, due to the large size of vultures, their menace to air craft has already been discussed in India (Singh, 1999). Other than electrocution, the large feather and forearm size of vultures also push them to risk of accidents with aircraft (Satheesan, 1994; Singh, 1999; Satheesan and Manjula, 2000).

DICLOFENAC CONTAMINATION

Many pharmaceutical agents are found to be described as the causative means to make toxicity in avian species including vultures (Meteyer *et al.,* 2005; Swan *et al.,* 2006a, 2006b; Taggart *et al.,* 2006). Involvement of drugs such as carprofen, flunixin, phenylbutazone and ibuprofen as the cause of death of vultures and other avian scavengers have been reported (Swan *et al.,* 2006b; Gilbert *et al.,* 2007a; Baral *et al.,* 2008; Ramakrishnani *et al.,* 2010). Diclofenac (2-[(2, 6-dichlorophenyl) amino] benzeneacetic acid, monopotassium salt) contamination from dead carcasses of cattle was a bright example and a special study made by several researchers to conclude to be a strong reason of vulture death. Diclofenac was first introduced in the UK in 1979 after it originated from Novartis (old name Ciba-Geigy) and then frequently used in many sectors of other countries (Salmann, 1986). Diclofenac has been used as non-steroidal-anti-inflammatory and analgesic agent (Oaks *et al.,* 2003, 2004a). Its use therefore, was restricted in human beings and domestic animals, especially in cattle and goats (Taggart *et al.,* 2007). According to Prakash *et al.* (2005) if 10– 20 per cent of the estimated 503 million livestock in India die annually and become available to vultures apart from a small proportion eaten by people, then a pharmaceutical industry estimate of 5 million annual diclofenac treatments would result in 5-10 per cent of carcasses being contaminated with detectable concentrations of diclofenac. However, given the short residence time of diclofenac, this would only be the case if all treated animals died within a week of being given diclofenac. Taggart *et al.* (2007) observed that 10 per cent diclofenac prevalence in samples from carcasses of domesticated ungulates. It suggests that considerably more than the estimated 5 million courses of treatment are given annually, and/or that the majority of animals treated are fatally ill (Taggart *et al.,* 2006).

As per the reports of American Society of Health-System Pharmacists during 2012, the half life of elimination of diclofenac is higher and solely species specific, the bioaccumulation and retention rate of diclofenac is much higher in comparison to the other anti-inflammatory and analgesic drugs. Therefore, bioaccumulation might be the main reason which could account to hamper the avian physiology those feed the carcasses of domestic animals treated with diclofenac (Naidoo and Swan, 2008). Long term administration of diclofenac may be resulted into severe pathologic conditions such as peptic ulceration, gastrointestinal bleeding, hepatotoxicity, renal papillary necrosis, and renal failure in animals followed by death (Arun and Azeez, 2004). After feeding on such contaminated carcasses, if the above symptoms are seen, then it indicates that diclofenac is the cause of vulture mortality. Now, let's analyze; whether this is the only major cause which is responsible for elimination of vulture population

Fig. 1 : The vultures in critically endangered state

Fig. 2 : Arboreal colonization of vulture

Fig. 3 : The vultures from Nepal cleaning the carcass

Fig. 4 : Cleaning the carcass, an ecofriendly measure

Fig. 5 : A group of vultures waiting for food

Fig. 6 : Vultures approaching a good meal in groups

Source: Fig. 1,2,4 and 5 - Journal of Biodiversity and Conservation, Vol. II (2010), Fig. 6- Current Science, Vol. 99 (2010), Fig. 3- www.birdlife.org

from many habitats worldwide including India. It is true that diclofenac contamination was traced in the carcasses of the vultures. If we hit this topic in pub med at the link in PubMed cite, we can find large number of articles available on the diclofenac related death of vultures. This can be a strong point to believe that diclofenac is the major cause of vulture mortality. On the other hand, none of the articles made it clear; whether diclofenac contamination was a "cause" or "effect" or "both cause and effect" of vulture death. Further, studies are also limited, to investigate the susceptibility of pathogens or other disorders to vultures after diclofenac contamination or diclofenac mediated death. Antimicrobial properties of diclofenac has been studied against microorganisms including *E. coli, M. tuberculosis* etc. (Mazumdar *et al.,* 2006; Dutta *et al.,* 2007a, 2007b). Cunningham *et al.* (2000, 2003) from their preliminary investigation have opined that an infectious disease probably with viral aetiology may not be the cause of the declining population of vultures. Although, they have concluded it since they did not find any pathogens in the carcasses of the studies vultures, it does not necessarily prove that vultures are not susceptible for infectious diseases because of the limitation of their area specific study. It might be possible that diclofenac may have a diverse effect on the physiology of the vultures both as an "effect" and also as a "cause" for susceptible for other pathogens as well as disorders leading to death. On the other hand, out of the 20 papers, one interesting article published very recently by Naidoo *et al.* (2011) that diclofenac can not be a strong cause to be predicted as a toxic agent in crow species but can be toxic to vulture species depending upon its half life of the rate of elimination from the body. However, still it has to be studied that vultures have multiple threats for their death other than diclofenac as the sole cause (Bird Life International, 2007).

OTHER CAUSES OF VULTURE MORTALITY, AN ANALYSIS

From the works of above reaserchers, it could be analyzed that diclofenac cannot be the sole or major cause of vulture extinction from the sub-continent. Followings can justify above.

(i) Prakash *et al.*(2005) found that against 10-20 % annual cattle death(out of 503 million livestock) 5-10 % being contaminated with diclofenac. The whole vulture populations which crashed must not have consumed the only contaminated 5-10 % carcass. Remaining 90-95 % carcass contamination with other chemicals and their impact on vultures have not been properly studied.

(ii) Naidoo and Swan(2008) studied that bio-accumulation might be the main reason hampering avian physiology.

(iii) According to Gilbert *et al.*(2007), neck drooping is due to high rise of environmental temperature.

(iv) Indian system of disposal is faulty. Always possibility of toxicity due to food poisoning. Again toxic fungal and bacterial growth could have been fatal. Also there is all possibility of community destruction, because they feed on groups (Fig. 6).

(v) Due to development process, we lost many tall trees and hence, their habitat and loss of species.

(vi) Farmers spray organo-phosperous compound over the carcass to prevent from foul smelling. Hundreds of vulture deaths due to contamination of pesticide have been reported by Oaks *et al.,* 2003, 2004a.

(vii) Also, apart from diclofenac, many other chemicals may be the cause of toxicity (Ramakrishnani *et al*., 2010).

(viii) Evolutionary process play major role in species extinction. By natural laws, species are vanished and new species are evolved. This finer aspects of nature has not been studied.

(ix) Some tribal population hunted them(Satheesan and Satheesan, 2000). Also food scarcity, frequent flood, cyclone, occurence of cannibalism

Perhaps this is for the first time that a major species is going to be extinct because of a chemical intervention. None of the researchers have exactly studied the lethal dose of diclofenac by which a vulture can die. In that case, a specific research be undertaken in a group of vultures and directly diclofenac in different concentration can be injected so that it can be exactly studied whether diclofenac is the actual culprit. Before the population crash, is there any record available in zoos and captive establishments of the subcontinent to check, if diclofenac has not been injected to vultures ? Now, since diclogfenac is completely banned and there have been many upcoming breeding programs in the country can our biologists, vets and scientific community be able to restore the population ?

REPORTS OF VARIOUS BOARDS ON INDIAN VULTURE CONSERVATION

Out of nine species of vultures recorded in India, two species namely the Indian white-backed (*Gyps bengalensis*) and long-billed (*G. indicus*) had the majority population among vultures in Indian subcontinent four decades ago. They are now on the verge of extinction and are classified as critically endangered by the IUCN. Although a rigorous effort by BNHS suggested that the declines are not related to either food shortage or habitat loss. Also toxicological background can not be the sole cause of their declining population; rather it is a multifunctional output of their physiological disorder which is to be keenly studied. A decade ago, the scenario was reviewed by the experts at the "International meeting on the vulture situation in India" held at Delhi, 18-20 September 2000, organized by the BNHS and supported by Royal Society for the Protection of Birds, United Kingdom and the Ministry of Environment and Forests, Government of India. The expert committee has decided a nation-wide monitoring program to identify the reasons of vulture population decline and to produce a recovery plan. Establishment of a captive care facility for sick and healthy vultures was another important issue as raised by the committee. Accordingly, Indian Vulture Disease Investigation Centre is serving over the past few years. BNHS and the Poultry Diagnostic Research Centre (PDRC), India in collaboration with Institute of Zoology, Zoological Society of London has been actively collaborating on vulture disease investigations in India and abroad. Darwin Vulture Project, one of the first activities of the project was to establish a dedicated vulture disease investigation centre at the PDRC in Pune. On 11th June 2001, India's premier Vulture Disease Investigative Centre was opened to investigate the reason of vulture declining. Then several workshops were organized. The workshop on "Monitoring bird population" was organized as part of the Darwin Vulture Project, in collaboration with the Forest and Wildlife Department of Haryana in January 2002. Various wildlife NGOs and wildlife departments, Indian Bird Conservation Network co-ordinators and researchers working on vultures from India and abroad participated in the workshop. They developed a common protocol for monitoring vulture populations, identifying *Gyps* spp., carcass collection and submission, post mortem examinations etc. The details of the plans are carefully explained, lunched and updated. A regular national training program also being opened for the interested researcher in collaboration with National Birds of Prey Centre, Newent, Gloustershire, U.K. A "Vulture Care Center" at Pinjore, District Panchkula, Haryana was established at Birshikargha Wildlife Sanctuary, Pinjore. Internationally, two reputed organisations are working on conservation of vulture population. According to Pain *et al.* (2008), the work of two main research groups was crucial in the search for the cause of declines and solutions. BNHS led one group, initially comprising Department of Forest, Haryana state, the RSPB, the Zoological Society of London (ZSL) and the National Birds of Prey Trust (NBPT), and later involved other national and international organizations. The second group comprised The Peregrine Fund (TPF), Washington State University and the Ornithological Society of Pakistan (OSP). Whilst the BNHS consortium focused largely on India, the TPF/OSP group conducted a complementary research programme in Pakistan and Bird Conservation Nepal (BCN).

RESEARCH LIMITATIONS

Now, it may be difficult to sacrifice vultures for further studies. Specific clearance from Deptt. of Forests and Environment, GOI may be extremely difficult. Very few colonies are left in the country. Analysing comparative study of chemicals/ toxic materials i.e. between diclofenac versus agricultural organophosperous compounds (which major Indian cattle consume through grazing) is difficult. Majorities of the carcasses have already been destroyed limiting the further studies.

FURTHER RESEARCH

Further research is desired to save a fantastic scavenger which would not only be beneficial to human but also to all other species of earth by maintaining the food chain.

(i) Diseased vultures should be identified and kept under definite care and supervision. It is believed that morbid birds exhibit signs of illness (may be neck drooping syndrome due to any reason) for approximately 30 days prior to death (Prakash *et al.,* 2003). Therefore, further investigations can be done

to investigate the causes of morbidity and mortality within a month. Analysis of the infected birds can draw a picture on their patho-physiology which yet has to be studied. The infected birds may be released after their full recovery.

(ii) Since the species is highly threatened, investigation on its health problems over its life cycle and pathogenesis is desired. India is ahead of taking steps for such plan for recovery of vultures. For that the rates of population decline of long-billed vulture, though rapid, are slowered down being 16 per cent per year than the catastrophic decline rates for oriental white backed vulture i.e. 44 per cent per year (Pain *et al.,*2008)

(iii) Vigorous research on the species biology and pathology is the order of the moment.

(iv) Proper funding for the research programs on vulture nesting, their roosting sites, breeding and feeding ecology etc. be taken care of.

(v) Research lab establishment and human awareness in and around the vulture community and fast reporting system.

(vi) General awareness of disposal of dead bodies in favor of vultures after ensuring that wild animals that had natural death and were free from contagious diseases be made available to the vultures. The awareness program against diclofenac contaminated cattle be undertaken to revive vulture population.

(vii) Proper health and nutritional care of vultures both in captive and in nature (if possible). 6. In captive breeding, rearing etc. of the species.

(viii) Identifying natural and artificial hazards and their remedial measures.

(ix) Regular workshops and hands on training program (for carcass submission, preliminary analysis, treatment of ill birds etc.) have to be organized on surveillance and monitoring of vultures.

(x) Steps may be taken to produce a genetically modified and programmed vulture race by manipulating the gene which can better fight against diseases and survive. If we have succeeded in programing other species such as goat for more meat, birds for more egg and meat, cattle for more milk, fishes for more flesh etc.; then why not vultures to make them fit for survival.

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