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SOME PROPERTIES OF DOUBLE HYPERGEOMETRIC FUNCTIONS OF MATRIX ARGUMENTS

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Abstract

The aim of the present paper is to study certain interrelations between the double hypergeometric functions of Appell, Humbert and Kampé de Fériet with matrix arguments by utilizing the Mathai's matrix transform technique.

Keywords: *Appell's functions, Humbert's function, Kampé de Fériet function, matrix arguments, matrix transform.*

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INTRODUCTION

The Appell's, Humbert's and the Kampé de Fériet functions of matrix arguments have earlier been studied by Mathai (1978, 1992, 1993 and 1995), Saxena, Sethi and Gupta (1997), Upadhyaya and Dhami(2001, 2002) and also by Upadhyaya(2003). The present paper is a continuation of the author's previous studies, as cited above, aimed at establishing certain properties of the double hypergeometric functions of matrix arguments of Appell, Humbert, and Kampé de Fériet by invoking the Mathai's definitions for these functions based on his technique of matrix transform. The matrices appearing in this paper are all real symmetric and positive definite with order $(p\times p)$ $A>0$ will mean that the matrix is positive definite, $A^{1/2}$ will represent the symmetric square root of A. While integrating over matrices $\int_X f(X)dX$ represents integral over X of the scalar function $f(X)$. $\mathrm{Re}(.)$ denotes the real part of $(.)$.

We begin with quoting some preliminary results and definitions which occur in the literature. Mathai (1978) defined the matrix transform (M- transform) of a function $f(X)$ of a $(p\times p)$ real symmetric positive definite matrix X as follows:

$$M_f(\rho)=\int_{X>0}|X|^{\rho-(p+1)/2}f(X)dX \qquad (1.1)$$

for $X>0$ and $\mathrm{Re}(\rho)>(p-1)/2$ whenever $M_f(s)$ exists.

The following results and definitions will be used in the proofs of various new results in the succeeding parts of this paper.

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Theorem 1.1: Mathai (1992, (eq. 2.24, p.23))- Let X and Y be $(p\times p)$ symmetric matrices of functionally independent real variables and A a $(p\times p)$ non singular matrix of constants. Then,

$$Y=AXA'\Rightarrow dY=|A|^{p+1}dX \tag{1.2}$$

and

$$Y=aX\Rightarrow dY=a^{p(p+1)/2}dX \tag{1.3}$$

where a is a scalar quantity.

Theorem 1.2: Type-1 Beta integral (Mathai (1993), eq. (2.2.2), p.34 and eq. (2.1.2), p.32)-

$$B_p(\alpha,\beta)=\int_{0<X<I}|X|^{\alpha-(p+1)/2}|I-X|^{\beta-(p+1)/2}dX=\frac{\Gamma_p(\alpha)\Gamma_p(\beta)}{\Gamma_p(\alpha+\beta)} \tag{1.4}$$

for $\mathrm{Re}(\alpha)>(p-1)/2,\mathrm{Re}(\beta)>(p-1)/2$ where,

$$\Gamma_p(\alpha)=\pi^{p(p-1)/4}\Gamma(\alpha)\Gamma(\alpha-\tfrac{1}{2})\cdots\Gamma(\alpha-\tfrac{p-1}{2}) \tag{1.5}$$

for $\mathrm{Re}(\alpha)>(p-1)/2$.

Theorem 1.3: Type-2 Beta integral: (Mathai (1993), eq.(2.2.4), p.36 and eq.(2.2.2), p.34)- For a real symmetric positive definite matrix Y,

$$B_p(\alpha,\beta)=\int_{Y>0}|Y|^{\alpha-(p+1)/2}|I+Y|^{-(\alpha+\beta)}dY=\frac{\Gamma_p(\alpha)\Gamma_p(\beta)}{\Gamma_p(\alpha+\beta)} \tag{1.6}$$

for $\mathrm{Re}(\alpha,\beta)>(p-1)/2$.

Theorem 1.4: Gamma integral (Mathai (1993), (eq. 2.1.3, p.33)- For real symmetric positive definite matrices X and B of order $(p\times p)$

$$\int_{X>0}|X|^{\alpha-(p+1)/2}e^{-tr(BX)}dX=|B|^{-\alpha}\Gamma_p(\alpha) \tag{1.7}$$

for $\mathrm{Re}(\alpha)>(p-1)/2$ where $tr(X)$ denotes the trace of the matrix X.

Theorem 1.5: (Upadhyaya (2003), eq.(3.60), p. 57)-

$$F_1(a,b,b';c;I,I)=\frac{\Gamma_p(c)\Gamma_p(c-a-b-b')}{\Gamma_p(c-a)\Gamma_p(c-b-b')} \tag{1.8}$$

provided that all the Γ_p's involved are defined.

Definition 1.1: For the ${}_rF_s$ function

$${}_rF_s={}_rF_s(a_1,\cdots,a_r;b_1,\cdots,b_s;-X)$$

$$M({}_rF_s)=\int_{X>0}|X|^{\rho-(p+1)/2}\,{}_rF_s(a_1,\cdots,a_r;b_1,\cdots,b_s;-X)dX$$
$$=\frac{\left\{\prod_{j=1}^{s}\Gamma_p(b_j)\right\}\left\{\prod_{k=1}^{r}\Gamma_p(a_k-\rho)\right\}\Gamma_p(\rho)}{\left\{\prod_{j=1}^{s}\Gamma_p(b_j-\rho)\right\}\left\{\prod_{k=1}^{r}\Gamma_p(a_k)\right\}} \tag{1.9}$$

for $\mathrm{Re}(a_k-\rho,b_j-\rho,\rho)>(p-1)/2$ where, $j=1,\cdots,s;k=1,\cdots,r$.

Definition 1.2: The Appell's function $F_1=F_1(a,b,b';c;-X,-Y)$ of matrix arguments is defined as that class of functions for which the M-transform (matrix-transform) is the following:

$$M(F_1)=\int_{X>0}\int_{Y>0}|X|^{\rho_1-(p+1)/2}|Y|^{\rho_2-(p+1)/2}F_1(a,b,b';c;-X,-Y)dXdY$$
$$=\frac{\Gamma_p(c)\Gamma_p(a-\rho_1-\rho_2)\Gamma_p(b-\rho_1)\Gamma_p(b'-\rho_2)\Gamma_p(\rho_1)\Gamma_p(\rho_2)}{\Gamma_p(a)\Gamma_p(b)\Gamma_p(b')\Gamma_p(c-\rho_1-\rho_2)} \tag{1.10}$$

for $\mathrm{Re}(a-\rho_1-\rho_2,b-\rho_1,b'-\rho_2,c-\rho_1-\rho_2,\rho_1,\rho_2)>(p-1)/2$.

Definition 1.3: For the Appell's Function F_2

$$F_2=F_2(a,b,b';c,c';-X,-Y)$$
$$M(F_2)=\int_{X>0}\int_{Y>0}|X|^{\rho_1-(p+1)/2}|Y|^{\rho_2-(p+1)/2}F_2(a,b,b';c,c';-X,-Y)dXdY$$
$$=\frac{\Gamma_p(c)\Gamma_p(c')\Gamma_p(a-\rho_1-\rho_2)\Gamma_p(b-\rho_1)\Gamma_p(b'-\rho_2)\Gamma_p(\rho_1)\Gamma_p(\rho_2)}{\Gamma_p(a)\Gamma_p(b)\Gamma_p(b')\Gamma_p(c-\rho_1)\Gamma_p(c'-\rho_2)} \tag{1.11}$$

for $\mathrm{Re}(a-\rho_1-\rho_2,b-\rho_1,b'-\rho_2,c-\rho_1,c'-\rho_2,\rho_1,\rho_2)>(p-1)/2$.

Definition 1.4: For the Appell's function F_4

$$F_4=F_4(a,b;c,c';-X,-Y)$$
$$M(F_4)=\int_{X>0}\int_{Y>0}|X|^{\rho_1-(p+1)/2}|Y|^{\rho_2-(p+1)/2}F_4(a,b;c,c';-X,-Y)dXdY$$
$$=\frac{\Gamma_p(c)\Gamma_p(c')\Gamma_p(a-\rho_1-\rho_2)\Gamma_p(b-\rho_1-\rho_2)\Gamma_p(\rho_1)\Gamma_p(\rho_2)}{\Gamma_p(a)\Gamma_p(b)\Gamma_p(c-\rho_1)\Gamma_p(c'-\rho_2)} \tag{1.12}$$

for $\mathrm{Re}(a-\rho_1-\rho_2,b-\rho_1-\rho_2,c-\rho_1,c'-\rho_2,\rho_1,\rho_2)>(p-1)/2$.

Definition 1.5: The Humbert's Ψ_2 function of matrix arguments

$$\Psi_2 = \Psi_2(a;c,c';-X,-Y)$$

is defined as that class of functions for which the M-transform is

$$M(\Psi_2) = \int_{X>0}\int_{Y>0} |X|^{\rho_1-(p+1)/2}|Y|^{\rho_2-(p+1)/2} \times \Psi_2(a;c,c';-X,-Y)dXdY$$

$$= \frac{\Gamma_p(c)\Gamma_p(c')\Gamma_p(a-\rho_1-\rho_2)\Gamma_p(\rho_1)\Gamma_p(\rho_2)}{\Gamma_p(a)\Gamma_p(c-\rho_1)\Gamma_p(c'-\rho_2)} \tag{1.13}$$

for $\mathrm{Re}(a-\rho_1-\rho_2, c-\rho_1, c'-\rho_2, \rho_1, \rho_2) > (p-1)/2.$

Definition 1.6: The Kampé de Fériet function $F_{s:m;n}^{r:q;k}$ of matrix arguments

$$F_{s:m;n}^{r:q;k} = F_{s:m;n}^{r:q;k}\left[\begin{matrix}(a_r):(b_q);(c_k)\\(\alpha_s):(\beta_m);(\gamma_n)\end{matrix}\middle| -X,-Y\right]$$

is defined as that class of functions which has the following M-transform:-

$$M\left(F_{s:m;n}^{r:q;k}\right) = \int_{X>0}\int_{Y>0} |X|^{\rho_1-(p+1)/2}|Y|^{\rho_2-(p+1)/2} \times F_{s:m;n}^{r:q;k}\left[\begin{matrix}(a_r):(b_q);(c_k)\\(\alpha_s):(\beta_m);(\gamma_n)\end{matrix}\middle| -X,-Y\right]dXdY$$

$$= \frac{\left\{\prod_{j=1}^{r}\Gamma_p(a_j-\rho_1-\rho_2)\right\}\left\{\prod_{j=1}^{q}\Gamma_p(b_j-\rho_1)\right\}}{\left\{\prod_{j=1}^{s}\Gamma_p(\alpha_j-\rho_1-\rho_2)\right\}\left\{\prod_{j=1}^{m}\Gamma_p(\beta_j-\rho_1)\right\}} \times \frac{\left\{\prod_{j=1}^{k}\Gamma_p(c_j-\rho_2)\right\}\left\{\prod_{j=1}^{s}\Gamma_p(\alpha_j)\right\}\left\{\prod_{j=1}^{m}\Gamma_p(\beta_j)\right\}}{\left\{\prod_{j=1}^{n}\Gamma_p(\gamma_j-\rho_2)\right\}\left\{\prod_{j=1}^{r}\Gamma_p(a_j)\right\}\left\{\prod_{j=1}^{q}\Gamma_p(b_j)\right\}} \times \frac{\left\{\prod_{j=1}^{n}\Gamma_p(\gamma_j)\right\}\Gamma_p(\rho_1)\Gamma_p(\rho_2)}{\left\{\prod_{j=1}^{k}\Gamma_p(c_j)\right\}} \tag{1.14}$$

for $\mathrm{Re}\big(a_j-\rho_1-\rho_2, j=1,\cdots,r;\alpha_j-\rho_1-\rho_2, j=1,\cdots,s;b_j-\rho_1, j=1,\cdots,q;$
$\beta_j-\rho_1, j=1,\cdots,m;c_j-\rho_2, j=1,\cdots,k;\gamma_j-\rho_2, j=1,\cdots,n;\rho_1,\rho_2\big)>(p-1)/2.$

RESULTS

Theorem 2.1:

$$\begin{aligned}&|I+X|^{-a}\,{}_2F_1\Big[a,b;c;-(I+X)^{-1/2}Y(I+X)^{-1/2}\Big]\\&=\frac{\Gamma_p(f+g)}{\Gamma_p(f)\Gamma_p(g)}\int_0^I|U|^{f-(p+1)/2}|I-U|^{g-(p+1)/2}\times\\&\qquad F_2\Big[a,f+g,b;f,c;-U^{1/2}XU^{1/2},-Y\Big]dU\end{aligned}\tag{2.1}$$

for $\mathrm{Re}(f,g)>(p-1)/2.$

Proof: Taking the M-transform the right side of eq.(2.1) with respect to the variables X and Y and the parameters ρ_1 and ρ_2 respectively, we have

$$\begin{aligned}&\int_{X>0}\int_{Y>0}|X|^{\rho_1-(p+1)/2}|Y|^{\rho_2-(p+1)/2}\times\\&F_2\Big[a,f+g,b;f,c;-U^{1/2}XU^{1/2},-Y\Big]dXdY\end{aligned}\tag{2.2}$$

Applying the transformations $X_1=U^{1/2}XU^{1/2}, Y_1=Y$ with $dX_1=|U|^{(p+1)/2}dX,\ dY_1=dY$ (from theorem (1.1)) and $|X_1|=|U||X|, |Y_1|=|Y|$ in eq.(2.2) and writing the M-transform of an F_2 function (definition (1.3)) we obtain,

$$\begin{aligned}&|U|^{-\rho_1}\frac{\Gamma_p(f)\Gamma_p(c)\Gamma_p(f+g-\rho_1)\Gamma_p(b-\rho_2)\Gamma_p(\rho_1)\Gamma_p(\rho_2)}{\Gamma_p(a)\Gamma_p(f+g)\Gamma_p(b)\Gamma_p(f-\rho_1)\Gamma_p(c-\rho_2)}\times\\&\Gamma_p(a-\rho_1-\rho_2)\end{aligned}\tag{2.3}$$

Substituting this expression on the right side of eq.(2.1) and integrating out U by using a type-1 beta integral (theorem (1.2)) we finally have

$$\frac{\Gamma_p(c)\Gamma_p(b-\rho_2)\Gamma_p(\rho_1)\Gamma_p(\rho_2)\Gamma_p(a-\rho_1-\rho_2)}{\Gamma_p(a)\Gamma_p(b)\Gamma_p(c-\rho_2)}\tag{2.4}$$

Now taking the M-transform of the left side of eq.(2.1) with respect to the variables X and Y and the parameters ρ_1 and ρ_2 respectively, we get

$$\int_{X>0}\int_{Y>0}|X|^{\rho_1-(p+1)/2}|Y|^{\rho_2-(p+1)/2}|I+X|^{-a}\times \\ {}_2F_1\left[a,b;c;-(I+X)^{-1/2}Y(I+X)^{-1/2}\right]dXdY \tag{2.5}$$

which on the application of the transformation $Y_2=(I+X)^{-1/2}Y(I+X)^{-1/2}$ (for a fixed X) with $dY_2=|I+X|^{-(p+1)/2}dY$ (from theorem (1.1)) and $|Y_2|=|I+X|^{-1}|Y|$ and then writing the M-transform of a ${}_2F_1$ function (definition (1.1)) and integrating out X by using a type-2 beta integral (theorem (1.3)) the last expression finally yields the same expression as in the eq.(2.4) thus proving the theorem.

Theorem 2.2:

$$e^{-tr(X+Y)} \\ =\frac{\Gamma_p(f+g)}{\Gamma_p(f)\Gamma_p(g)}\int_0^I|U|^{f-(p+1)/2}|I-U|^{g-(p+1)/2}\times \\ \Psi_2\left[f+g;f,g;-U^{1/2}XU^{1/2},-(I-U)^{1/2}Y(I-U)^{1/2}\right]dU \tag{2.6}$$

for $\mathrm{Re}(f,g)>(p-1)/2.$

Proof: Taking the M-transform the right side of eq.(2.6) with respect to the variables X and Y and the parameters ρ_1 and ρ_2 respectively, we get,

$$\int_{X>0}\int_{Y>0}|X|^{\rho_1-(p+1)/2}|Y|^{\rho_2-(p+1)/2}\times \\ \Psi_2\left[f+g;f,g;-U^{1/2}XU^{1/2},-(I-U)^{1/2}Y(I-U)^{1/2}\right]dXdY \tag{2.7}$$

which on utilizing the transformations $X_1=U^{1/2}XU^{1/2},Y_1=(I-U)^{1/2}Y(I-U)^{1/2}$ with $dX_1=|U|^{(p+1)/2}dX,dY_1=|I-U|^{(p+1)/2}dY$ (from theorem(1.1)) and $|X_1|=|U||X|,|Y_1|=|I-U||Y|$ followed by writing the M-transform of a Ψ_2 function (definition (1.5)) renders

$$|U|^{-\rho_1}|I-U|^{-\rho_2}\frac{\Gamma_p(f)\Gamma_p(g)\Gamma_p(f+g-\rho_1-\rho_2)\Gamma_p(\rho_1)\Gamma_p(\rho_2)}{\Gamma_p(f+g)\Gamma_p(f-\rho_1)\Gamma_p(g-\rho_2)} \tag{2.8}$$

Substituting this expression on the right side of eq.(2.6) and integrating out U by using a type-1 beta integral (theorem (1.2)) yields

$$\Gamma_p(\rho_1)\Gamma_p(\rho_2) \tag{2.9}$$

Similarly taking the M-transform of the left side of eq.(2.6) with respect to the variables X and Y and the parameters ρ_1 and ρ_2 respectively and integrating out X and Y by utilizing a gamma integral (theorem (1.4)) produces the same result as in eq.(2.9) thereby establishing the theorem.

Theorem2.3:

$$F_{0:2;1}^{2:1;0}\left[\begin{matrix} a,b: & f; & - \\ -: & f+g,c;c' \end{matrix}\middle| -X,-Y\right]$$

$$= \frac{\Gamma_p(f+g)}{\Gamma_p(f)\Gamma_p(g)}\int_0^I |U|^{f-(p+1)/2}|I-U|^{g-(p+1)/2}\times \tag{2.10}$$

$$F_4\left[a,b;c,c';-U^{1/2}XU^{1/2},-Y\right]dU$$

for $\mathrm{Re}(f,g)>(p-1)/2.$

Proof: Taking the M-transform the right side of eq.(2.10) with respect to the variables X and Y and the parameters ρ_1 and ρ_2 respectively, we obtain

$$\int_{X>0}\int_{Y>0}|X|^{\rho_1-(p+1)/2}|Y|^{\rho_2-(p+1)/2}\times$$

$$F_4\left[a,b;c,c';-U^{1/2}XU^{1/2},-Y\right]dXdY \tag{2.11}$$

which on the application of the same set of transformations as has been used in the first step of the proof of the theorem (2.1) and writing the M-transform of an F_4 function (definition (1.4)) leads to

$$|U|^{-\rho_1}\frac{\Gamma_p(c)\Gamma_p(c')\Gamma_p(a-\rho_1-\rho_2)\Gamma_p(b-\rho_1-\rho_2)\Gamma_p(\rho_1)\Gamma_p(\rho_2)}{\Gamma_p(a)\Gamma_p(b)\Gamma_p(c-\rho_1)\Gamma_p(c'-\rho_2)} \tag{2.12}$$

which on putting on the right side of eq.(2.10) and integrating out U by applying a type-1 beta integral (theorem (1.2)) generates

$$\frac{\Gamma_p(f+g)\Gamma_p(c)\Gamma_p(c')\Gamma_p(f-\rho_1)\Gamma_p(\rho_1)\Gamma_p(\rho_2)}{\Gamma_p(f)\Gamma_p(a)\Gamma_p(b)\Gamma_p(c-\rho_1)\Gamma_p(c'-\rho_2)\Gamma_p(f+g-\rho_1)}\times \tag{2.13}$$

$$\Gamma_p(a-\rho_1-\rho_2)\Gamma_p(b-\rho_1-\rho_2)$$

The same result is obtained by taking the M-transform of the left side of eq.(2.10) with respect to the variables X and Y and the parameters ρ_1 and ρ_2 respectively and writing the M-transform of the Kampé de Fériet function involved by the help of definition (1.6), hence, proving the theorem.

Theorem 2.4:

$$F_1[a,b,b';f+g;-X,-Y]$$

$$=\frac{\Gamma_p(f+g)}{\Gamma_p(f)\Gamma_p(g)}\int_0^I |U|^{f-(p+1)/2}|I-U|^{g-(p+1)/2}\times \tag{2.14}$$

$$F_2\left[a,b,b';f,g;-U^{1/2}XU^{1/2},-(I-U)^{1/2}Y(I-U)^{1/2}\right]dU$$

for $\mathrm{Re}(f,g)>(p-1)/2.$

Proof: Taking the M-transform the right side of eq.(2.14) with respect to the variables X and Y and the parameters ρ_1 and ρ_2 respectively and then using the same set of transformations as have been utilized in the first step of the proof of the theorem (2.2) and appealing to the M-transform of an F_2 function (definition (1.3)) leads to the M-transform of an F_1 as given by the definition(1.2) thus finishing the proof.

On letting $X\to -I, Y\to -I$ in the theorem (2.4) and then applying the theorem (1.5) leads us to the following interesting result.

$$\int_0^I |U|^{f-(p+1)/2}|I-U|^{g-(p+1)/2}\times$$

$$F_2[a,b,b';f,g;-U,-(I-U)]dU \tag{2.15}$$

$$=\frac{\Gamma_p(f)\Gamma_p(g)\Gamma_p(f+g-a-b-b')}{\Gamma_p(f+g-a)\Gamma_p(f+g-b-b')}$$

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SYNERGISTIC MODULATION OF CADMIUM INDUCED TESTICULAR TOXICITY IN BALB/C MICE BY *WITHANIA SOMNIFERA* AND VITAMIN E

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Abstract

Present study investigated modulatory potential of *Withania somnifera* and vitamin E on cadmium induced testicular injury in BALB/c mice. Cadmium exerts systemic toxic effects in animals and humans and has been classified as a human carcinogen. *Withania somnifera*, a potent antioxidant, exhibits hepatoprotective, anti-inflammatory and anticancerous effects while vitamin E exerts antioxidant activity. CdSO administration (intraperitoneal, 5 mg/kg b.wt.), for 5 days revealed marked alterations in lipid peroxidation and antioxidant levels. Histopathology displayed degeneration of the spermatogenic cell layer, defoliation of many spermatocytes and seminiferous tubules, diffused necrosis and apoptosis of Leydig cells. On the contrary, *Withania somnifera* (500 mg/kg b.wt.) administration to cadmium treated mice showed signs of recovery and decreased necrosis. In addition, vitamin E treatment (100 mg/kg b.wt.) supplementation synergistically ameliorated cadmium induced structural and biochemical changes and demonstrated normal histoarchitecture. Thus, *Withania somnifera* and vitamin E ameliorates cadmium induced structural alterations and restores normal tissue architecture and functioning.

Keywords: Cadmium, *Withania somnifera*, Vitamin E, Testes.

INTRODUCTION

Heavy metals are perilous as they tend to bioaccumulate and cannot be degraded or destroyed (Satarug and Moore, 2004). Cadmium, a well-known heavy metal has been ranked as the 7th most hazardous metal amongst the top 20 hazardous substances priority list (ATSDR, 2011). Cadmium exposure is strongly associated with reproductive toxicity in both animal and human populations culminating in infertility and cancer of reproductive tissues (Barlow and Sullivan, 1982; Akinloye *et al.*, 2006). The most spectacular manifestation of cadmium toxicity in testes is highly reduced sperm count resulting in infertility (Ola-Mudathir *et al.*, 2008).

Though great advances have been made in modern medical system for the cure and prevention of heavy metal toxicity during the last century but a defined treatment still seems to be lacking. Therefore, to investigate novel and safe therapies, present scientific interest is focused towards traditional medicine system. *Withania somnifera*, popularly known as Ashwagandha, is a widely used herb in Ayurveda. Withaferin A (WFA) and withanolide are its prime active components lending antioxidant properties to *Withania* (Kaur *et al.*, 2004; Mayola *et al.*, 2011). *Withania somnifera* exhibits other biological activities like anti-stress (Archana and Namasibayam, 1999), immunomodulatory (Agarwal *et al.*, 1996) and anti-tumorogenicity (Sharada *et al.*, 1996). *Withania somnifera* therefore potentiates for a natural alternative or as an adjunct with conventional agents with no side effects (Patil *et al.*, 2012).

Vitamin E, a major free radical chain-breaking endogenous antioxidant, interferes with initiation and progression of cadmium-induced oxidative damage. As a primary liposoluble antioxidant, it scavenges free oxygen radicals and stabilizes the cell membranes, maintaining their permeability (Beyer, 1994). Therefore, the present study was aimed to investigate the concurrent effects of *Withania somnifera* and vitamin E against cadmium mediated toxicity by biochemical and histopathological parameters.

MATERIALS AND METHODS

Animals and treatment

For the present investigations, BALB/c mice (weighing 25-30 gm) were used. All animals were acclimatized for a period of 7 days, fed standard rat pellet diet (Ashirwad Industries, India), and water *ad libitum*. Animals were divided into control group, cadmium group (Cd) (5mg/kg b.wt. for 5 days), *Withania somnifera* (W) group (aqueous extract, 500mg/kg b.wt., orally), Cd + *Withania* (Cd+W) group, Vitamin E (E) group (100mg/kg b.wt., orally), Cd+ Vitamin E, Cd + *Withania* + Vitamin E (Cd+W+E) simultaneously.

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Biochemical estimations: Homogenate (10%) and post mitochondrial supernatants of testes were prepared and various biochemical tests were performed.

Oxidative stress parameters: Lipid peroxidation, an index of oxidative stress was measured by the method of Beuge and Augst (1978).

Enzymatic and non-enzymatic antioxidants: Reduced glutathione was determined in the homogenate by the method of Beutler *et al.* (1963). Catalase (CAT) activity was assayed by following the decrease of H_2O_2 at 240 nm by the method of Luck (1971). Superoxide dismutase (SOD) was determined by measuring inhibition in the rate of NBT reduction by SOD present in the enzyme source by the method of Kono (1978). The activity of Glutathione-S-transferase (GST) was measured in the PMS by the method of Habig *et al.* (1974). Protein content was assayed in homogenate and PMS of testes by the method of Lowry *et al.* (1951).

Light microscopy: The structural changes in testes were evaluated by histopathological studies (Pearse, 1968). For light microscopy, tissue was fixed in Bouin's and embedded in paraffin wax. The 5 micron thick sections were cut by rotary microtome and stained with haematoxylin and eosin and then examined under light microscope (Leica DC 100, PCI Interface Digital Camera).

Statistical analysis: All values were expressed as means ± standard deviation of six animals per group (n=6). The data was analyzed using unpaired Student's t-test.

RESULTS

Acute exposure of cadmium (5mg/kg b.wt.) for 5 days caused statistically significant enhancement ($p<0.0001$) in testicular LPO levels (~35%). Administration of *Withania somnifera* to cadmium intoxicated mice moderately reinstated the levels of lipid peroxidation in testes. Concomitant administration of *Withania somnifera* and vitamin E brought down the levels of lipid peroxidation to near control values (Table1). Cadmium intoxication caused a statistically significant (pd"0.001) fall in levels of GSH (71%) in testes, while treatment with *Withania somnifera* significantly restored the levels of GSH. Concurrent treatment with *Withania somnifera* and vitamin E in cadmium treated group for 5 days maintained the level of this non-enzymatic anti-oxidant values to near normal range.

Five days cadmium treatment significantly decreased catalase (56%) and SOD (79%) levels in testes. Administration of *Withania somnifera* to cadmium treated mice revealed marked improvement with approximately 20% and 50% increase in their levels respectively. Concurrent treatment of *Withania somnifera* and vitamin E to the cadmium treated mice brought the catalase and SOD levels to near normal values testicular tissues.

Cadmium intoxication resulted in an extremely significant (pd"0.0001) decline in testicular GST (82%). Though the treatment of *Withania somnifera* showed enhancement in the levels of testicular GST, concurrent administration of *Withania somnifera* and vitamin E further increased the levels of GST approaching control values.

Histopathology of testes

Testes of control group revealed a number of seminiferous tubules, each lined by germinal epithelium. Four to five concentric layers of spermatogenic cells were seen revealing primary and secondary spermatocytes and spermatids. Numerous spermatozoa were visible in the lumen of each seminiferous tubule. Leydig cells appeared amid the interstitial space between two tubules (Fig. 1 A, B). Histology of *Withania somnifera* and vitamin E treated groups revealed normal morphology histoarchitecture of testes (Fig. 2 A, B).

Histopathological examination of cadmium treated testes displayed extensive testicular damage. Germinal cell layer was seen detached from the basal membrane and germ cells were destructed. Necrosis was diffused throughout the tissue. Spermatogenic cell layers were sloughed off and defoliation of many spermatocytes into lumen and seminiferous tubules appeared leading to oligospermia. Many seminiferous tubules were atrophied. More interstitial space was observed due to edema and congestion. Apoptosis of Leydig cells and degeneration of sertoli cells was also seen (Fig. 1 C, D).

Withania somnifera treatment to cadmium treated mice restored some of the structural alterations caused by cadmium (Fig. 3 A, B). Mild interstitial edema and few degenerated spermatocytes were noticed. Lumen of seminiferous tubules was filled with seminal plasma and spermatocytes. This group revealed moderate improvement in the testes structure in comparison to

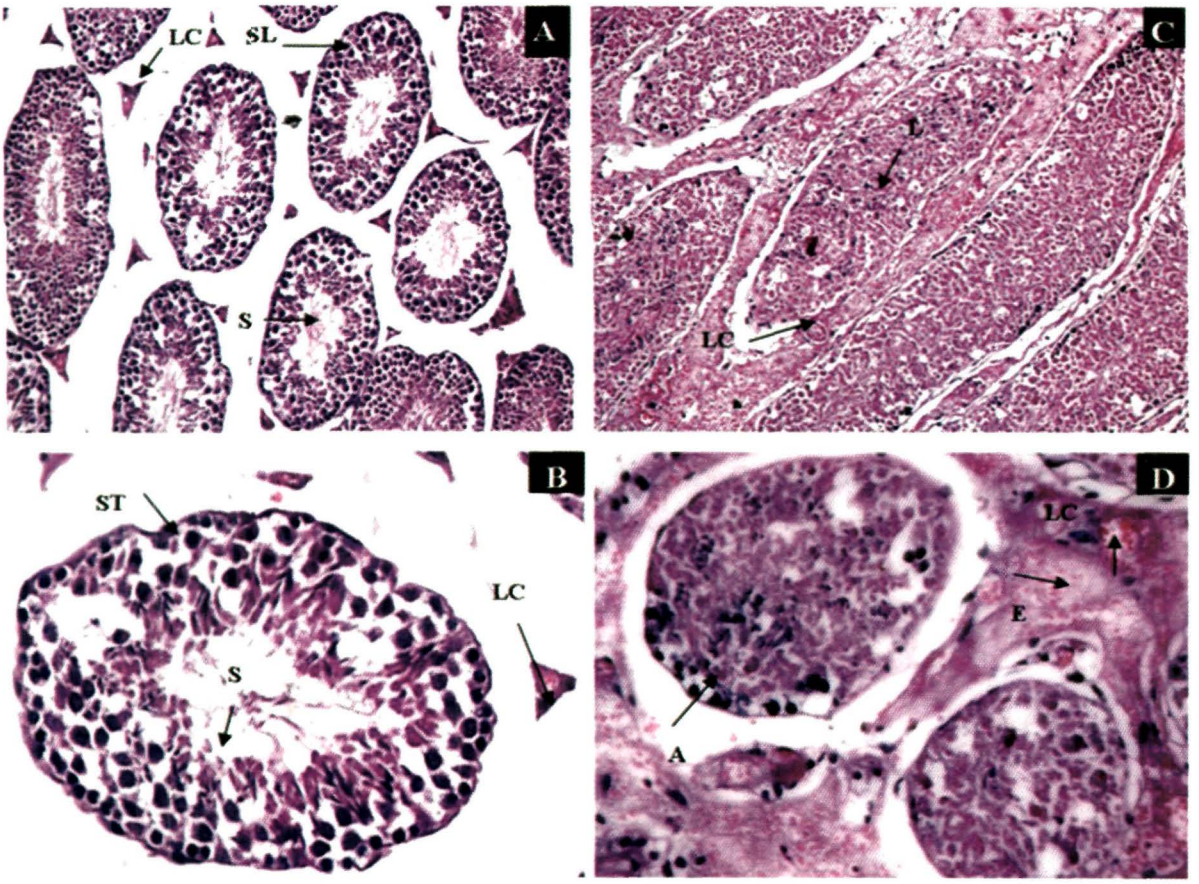


Fig. 1: Light micrography showing comparison of control (C) and Cd treated (Cd) testes.
A:Normal histoarchitecture of testes showing seminiferous tubules in control, seminiferous tubule showing concentric layers of spermatogonia and lumen filled with sperms, Leydig cells present in the interstitial space in control (20X); B: Magnified view of normal seminiferous tubule and Leydig cells in control (40X); C: Extensively damaged spermatogonia in the seminiferous tubules with interstitial edema, diffused necrosis in whole tissue with damaged layers of spermatoginia and lumen filled with cells, sperms absent and destroyed Leydig cells in Cd (20X); D: Atrophied seminiferous tubule lacking different developing stages of spermatogenesis and sperms. Interstitial space revealing massive edema in Cd (40X).

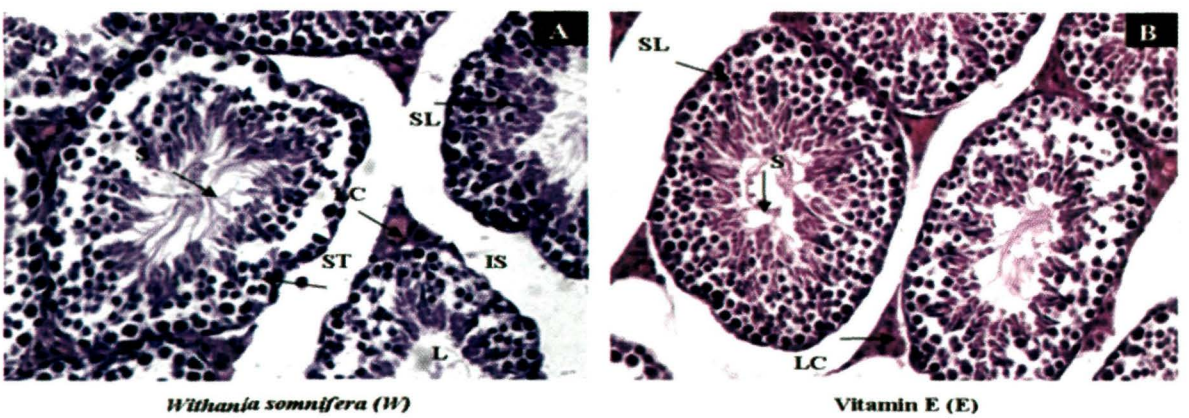
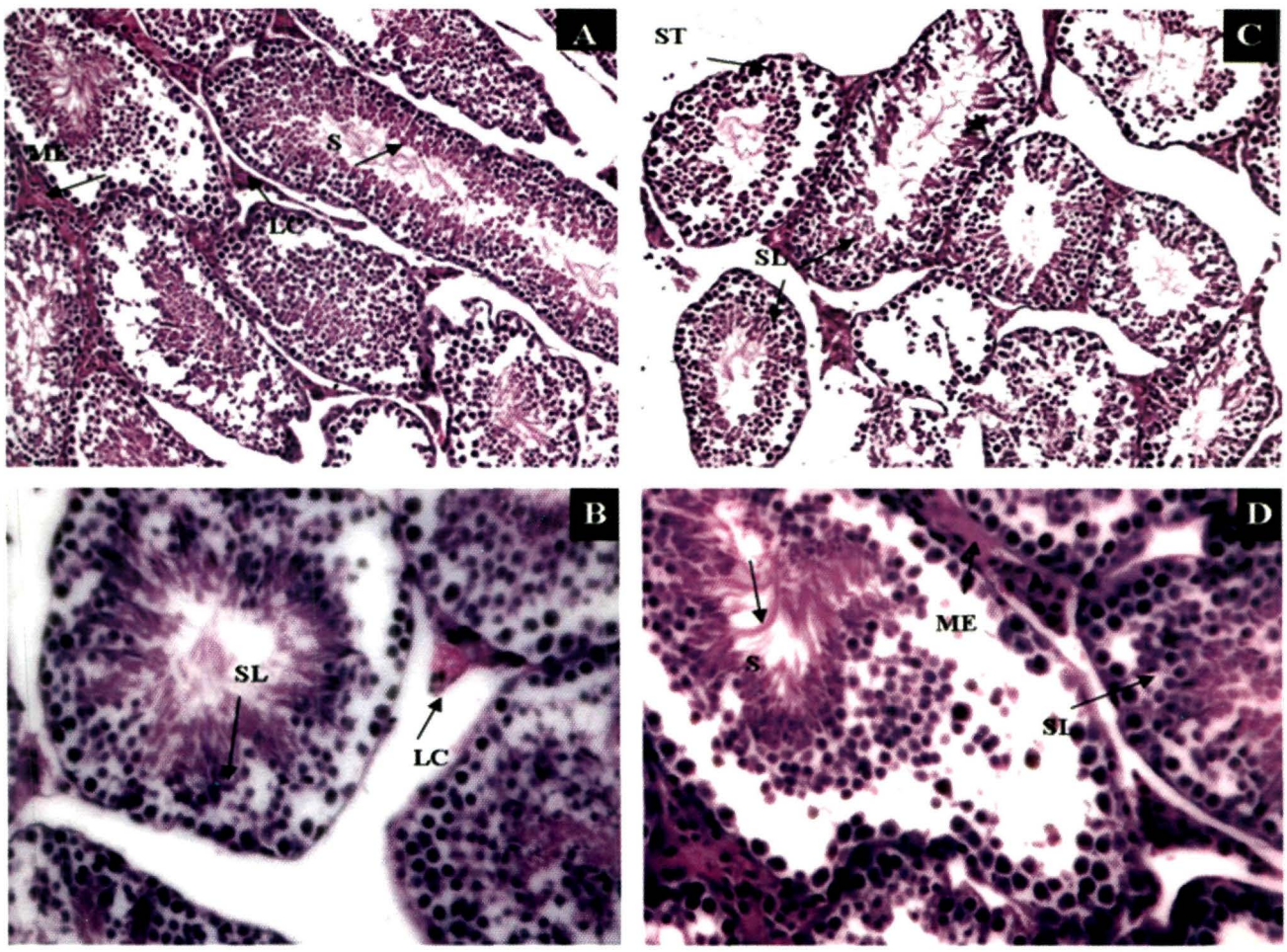


Fig.2 Light micrographs showing histology of *Withania somnifera* treated (W) and vitamin E treated (E) mice. A, B: Sections showing normal histoarchitecture of testes with numerous seminiferous tubules in W and E mice repectively (40X).

cadmium treated groups. Nevertheless, concurrent treatment of *Withania somnifera* and vitamin E of cadmium treated mice exhibited enormous signs of improvement as compared to cadmium treated mice (Fig. 3 C, D). Numerous spermatozoa were visible in the lumens of tubules. Most of the structural alterations were reversed and testes exhibited nearly normal histoarchitecture.

DISCUSSION

Cadmium evokes toxicity through production of reactive oxygen species due to its inhibitory effects on mitochondrial electron transport (Tatrai *et al.*, 2001). The reactive oxygen species react with lipids, proteins and nucleic acids causing lipid peroxidation, membrane



Cadmium + *Withania* **Cadmium + *Withania* + Vit E**

Fig. 3: Light micrograph showing comparison of modulation of cadmium toxicity by *Withania somnifera* alone and in combination with vitamin E. A: Mild interstitial edema and slightly damaged germinal cells (20X); B: Seminiferous tubules with different spermatogonial and spermatocytes stages and numerous sperms in the lumen (40X); C: Seminiferous tubules with normal spermatogonial cell layers and sperms in lumen (20X); D: Normal seminiferous tubules with different stages of spermatogenesis and numerous sperms in the lumen (40X).

damage and enzyme inactivation affecting cellular metabolism (Stohs *et al.*, 2000). In the present study, a significant increase in the lipid peroxidation was observed in testes after 5 days of cadmium exposure. These observations are in concert with the findings of Mehana (2008). Furthermore, cadmium reduced the levels of testicular GSH, lending support from the observations of Mehana (2008) and Mohamed and Mohamed (2009). It has been suggested that cadmium inhibits GSH by its binding to the thiol group of cysteine (Waisberg *et al.*, 2003). The observed decrease in the levels of CATon cadmium treatment is plausibly due to

Table 1: Effect of cadmium and its modulation by *Withania somnifera* (W) and vitamin E (E) on antioxidant defence system in testes

Testes	Control	Cd	*W*	E	Cd + *W*	Cd + E	Cd + *W* + E
LPO (nmoles/mg protein)	2.256 ± 0.0115	3.05 ± 0.002***	2.18 ± 0.014	2.265 ± 0.106	2.815 ± 0.021***	2.931 ± 0.019***	2.605 ± 0.007***
GSH (µmoles/min/mg protein)	0.1207 ± 0.009	0.0346 ± 0.0045**	0.1140 ± 0.0028	0.1032 ± 0.0025	0.0635 ± 0.0016**	0.0586 ± 0.0013**	0.0833 ± 0.0057*
SOD (units/min/mg protein)	47.537 ± 1.874	9.945 ± 0.276***	42.91 ± 0.868	43.52 ± 1.131	29.82 ± 1.202**	25.14 ± 1.009**	38.665 ± 1.93*
CAT (µmoles/min/mg protein)	32.413 ± 3.063	14.245 ± 0.262**	27.49 ± 0.127	37.765 ± 5.692	20.14 ± 0.537*	18.32 ± 0.478*	27.05 ± 0.368
GST (µmoles/min/mg protein)	0.673 ± 0.018	0.116 ± 0.0014***	0.636 ± 0.019	0.623 ± 0.018	0.385 ± 0.0134***	0.326 ± 0.0129***	0.541 ± 0.0092**

Values are shown as Mean ± S.D. (n = 6).
Levels of significance: * = $p<0.05$ (statistically significant); * *= $p\leq0.001$ (very statistically significant); ***= $p\leq0.0001$ (extremely statistically significant).

accumulation of superoxide radicals and hydrogen peroxide radicals (Ramesh and Satakopan 2010). The production of lipid peroxidation, depletion of glutathione and direct binding of cadmium to the enzyme active site possibly inhibited the activity of antioxidant enzymes viz. catalase, superoxide dismutase and glutathione-S-transferase (Nagaraj *et al.*, 2000).

Testes are extremely sensitive to cadmium exposure (Siu *et al.*, 2009). Histopathological analysis of 5 days cadmium treated testes revealed extensive cellular and extracellular tissue damage. Degenerated spermatogonial cells, decreased number of sperms, destruction of Leydig cells and interstitial edema were evidently observed in cadmium treated mice testes. The pathogenesis of testicular damage and sperm abnormalities induced by cadmium exposure is generally attributed to oxidative damage via production of reactive oxygen species (Yang *et al.*, 2006). Hew *et al.* (1993) suggested that reduction in sperm count might be a direct outcome of increased and consistent lipid peroxidation and altered membrane properties that leads to germ cell death at different stages of development. Therefore, observations of Hew *et al.* (1993) support present biochemical and histopathological findings by suggesting lipid peroxidation as the prime indicator of testicular damage. Moreover, increased sperm membrane lipid peroxidation is suspected to obstruct sperm motility, increased percentage of total sperm abnormalities and loss in fertilising potential of sperm (El-Demerdash *et al.*, 2004).

Antioxidant potential of *Withania somnifera*

In the present study, administration of *Withania somnifera* to cadmium treated mice caused significant reduction in their lipid peroxidation levels. These observations fetch support from the findings of Bhatnagar *et al.* (2005) and Mirjalali *et al.* (2009) which illustrated the antioxidant potential and free radical scavenging activity of *Withania* (Bhattacharya *et al.*, 1997). In the present study increased levels of SOD, CAT, GST and GSH in cadmium intoxicated mice following *Withania somnifera* suggested the free radical scavenging activities of biochemically active constituents of *Withania* viz. alkaloids and flavanoids.

These observations are in concert with similar findings of Bhatnagar *et al.* (2005), Prithiviraj *et al.* (2013). Furthermore, Toyokuni *et al.* (2003) and Ranaivo *et al.* (2004) also suggested that flavanoids and polyphenols stimulate SOD and CAT gene transcription and thus enhance their levels.

Withania somnifera has been used as a tonic in spermatopathia, impotence and seminal depletion (Williamson, 2002). In the present study, *Withania somnifera* recovered the normal histoarchitecture of testes and increased the number of sperms in the lumen. Mild interstitial edema was observed but Leydig cells were almost normal. In the present study, *Withania somnifera* might therefore, have enhanced the levels of testosterone that restored the apoptotic damage caused by cadmium.

Modulatory potential of vitamin E

Co-administration of vitamin E and *Withania somnifera* significantly declined lipid peroxidation in cadmium treated mice. Vitamin E, a powerful antioxidant, enhanced the antioxidant potential of *Withania somnifera* through its chain breaking potential (Gulec *et al.*, 2006). Most likely vitamin E reduced oxidative stress through rebalancing the impaired prooxidant/ antioxidant ratio (Hsu and Gue, 2002). The observed improvement in antioxidant enzyme systems might be the result of free radical scavenging effects of vitamin E (Gurel *et al.*, 2005).

Vitamin E is also considered as an anti-sterility vitamin (Uzunhisarcikli *et al.*, 2007) and is essential for normal spermatogenesis (Mason and Mauer, 1975). It has been reported to reduce oxidative stress in testes (Kutlubay and Oguz, 2007; Aitken and Romanm, 2008). In the present study, biochemical findings supported histopathology suggesting concurrent administration of vitamin E and *Withania somnifera* as a plausible modulator against cadmium toxicity. Histomicrographs depicted normal seminiferous tubules and numerous sperms in the lumens of seminiferous tubules. Interstitial space and Leydig cells were also normal. Mather *et al.* (1983) proposed that vitamin E restores normal number of sperms by secreting human chorionic gonadotrophin stimulated testosterone thus may potentially provide the mechanism for antifertility.

It can therefore be concluded from the present study that *Withania somnifera* and vitamin E concomitantly modulate the effects of cadmium and could be exploited as an effective drug supplement against cadmium induced testicular damage.

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Abbreviations:

A– atrophy
E– edema
IS– interstitial space
L– lumen
LC– Leydig cells
ME– mild edema
S– sperms
SL– spermatogonial layers
ST– seminiferous tubule

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A THEORITICAL STUDY ON MULTIPLE BIOMETRIC TRAITS FOR PERSON IDENTITY

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Abstract

Today's world is highly technology driven which starts from computers to information driven. Even though, information driven attempt to lack identity and authenticate a person where as bio-informatics resolve it using biometrics. Every countries adapt to authorize a person to enter a restricted area (in lieu of requiring the person to carry a pass card), User identification at an ATM (remember a PIN), Use of the print as a seal of authenticity in lieu of a signature. The methods citied are easily duplicated and less security is available.

In recent years, biometric authentication has seen considerable improvements in reliability and accuracy, where as some biometrics offering reasonably good and improved performance. However, even the best biometrics up to date is still facing numerous problems, some of them inherent to the technology itself.

Biometric authentication expressed in the form of uni-biometric trait in traditional days, which often causes inconsistency to identify a person, which leads to focus more attention on Multi-biometric issues. Multi-biometrics is a relatively new approach which yields good performance in authenticating person. This system uses multiple sensors for data acquisition. Normally, the Biometric authentication system consists of four main stages such as Sensor, Feature extraction, Matcher and Database which is a common framework for Multi-biometric authentication too. Many developed countries adopted multi-biometric system, like wise India also introduces Aadhaar card for unique identity. In this article, multi-biometric authentication issues are discussed without going into the mathematical details.

Keywords: *Uni-biometric, Multi-Biometric authentication and Data acquisition.*

INTRODUCTION

The identity of a person derived from the following factors such as "something you know" (e.g., Name, surname, residential proof) "something you carry" (e.g., physical key, ID card) and "something you are" (e.g., face, voice) (IBM Corporation). In olden days, person's identity include Knowledge-based (e.g., passwords) and token-based (e.g., ID cards) mechanisms which are very easy to duplicate and often causes less security.

Biometrics plays a vital role to identify the individuals and deployed to develop Security all over the world. The word biometrics is derived from the ancient Greek words 'bios' and 'metron' meaning life and measure, respectively. The biometric refers to recognition of human identity based on their behavioral and/or physical characteristics. Examples of physical characteristics includes iris, face, fingerprints, retina, hand geometry, vascular patterns (in the palm, finger, eye etc.), while behavioral characteristics include signature, gait, keystroke dynamics (typing).Voice is a combination of both physical and behavioral characteristics.

Biometrics which offers a natural and reliable solution to certain aspects of identity management by utilizing fully automated or semi-automated schemes to recognize individuals based on their inherent physical and/or behavioral characteristics by using biometrics (Jain et al., 2004) (see Fig. 1).

The precedence of authenticating a person leads by physical characteristics rather than behavioral. When comparing behavioral with physical, behavioral characteristics subject to change periodically whereas physical it is not so easy. Whereas Voice can be considered either as an anatomical or as a behavioral trait because Certain characteristics of a person's voice such as pitch, bass/tenor and nasality are due to physical factors like vocal tract shape, and other characteristics such as word or phoneme pronunciation (e.g., dialect), use of characteristic words or phrases and conversational styles are mostly learned which also causes inconsistent information to authenticate person.

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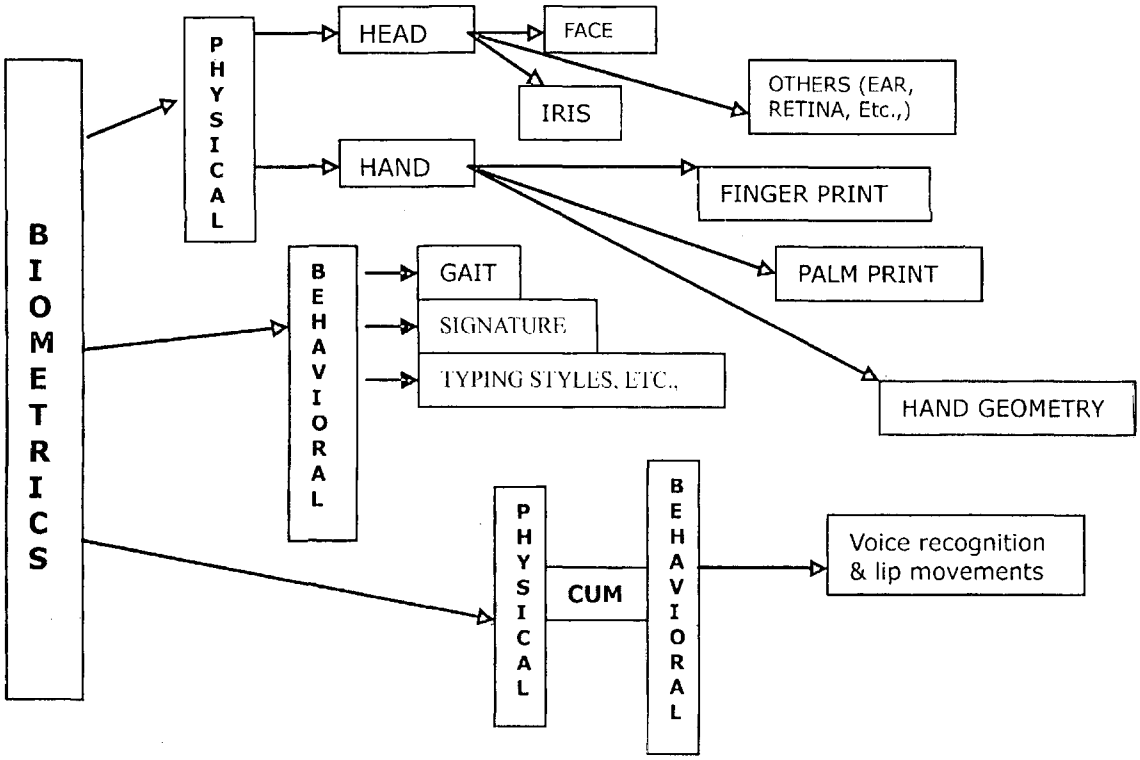

Fig. 1: Various Biometric Representations

Most biometric systems deployed in real world applications are mono-representation, i.e. only one source of information is used for authentication. These systems often face numerous limitations, such as, susceptibility of the result to quality of the sample, its orientation/rotation and distortion, noise, intra-class variability, non-distinctiveness, non-universality, and others. To justify the correct biometric solution user needs to consider these three factors Such as: Type I errors, Type II errors, and crossover error rate (CER). When an authorized individual is rejected by a biometric system—termed false reject—this is a Type I error. When an intruder is falsely accepted by a biometric system—termed false accept—this is a Type II error. The CER is a percentage rating of Type I versus Type II errors. A lower CER rate means better accuracy.

Now a day, Security seems to be prime importance in each and every corner of the world. Security measures identified through the biometric systems that are more influenced rather than earlier methods. Recently, Many countries adapt single biometric trait to establish identity (i.e., they are uni-biometric systems) in many application areas. Some of the problems encountered by uni-biometric system are listed below.

(I) Noise in sensed data: imperfect acquisition conditions.

(II) Spoof attacks: Behavioral traits such as voice and signature are vulnerable to spoof attacks by an impostor attempting to mimic the traits corresponding to legitimately enrolled subjects. Physical traits such as fingerprints can also be spoofed by inscribing ridge-like structures on synthetic material such as gelatine.

Each biometric trait has its own adv0antages and limitations, and no single trait is expected to meet all the requirements such as accuracy, practicality and cost imposed by all applications. Therefore, there is no universally best biometric trait and the choice of biometric depends on the nature and requirements of the application (Jain et al., 2004).Biometric systems that cover only a single biometric trait are generally unable to provide the desired performance requirements as they suffer from problems like: noisy-data, spoof attacks, non-universality, insufficient population coverage, and improper sensor adjustment. To overcome these difficulties multi-biometric systems are used (Singhal and Jain (2012).Some of the limitations imposed

by mono-representation biometric systems can be overcome by including multiple sources of information for establishing easy identity. Such systems are known as Multi-biometric Systems. In simpler terms, multi bio metric system: = Physical traits + Logical traits + Physical cum logical traits.

MULTI-BIOMETRICS: OVERVIEW

Recently, many researchers focus their attention on multibiometrics which improves the authenticity of human identity at very high percentage. Multibiometrics is a novel approach which is interrelated and integrated by various biometric traits collected from the individual. The multi-biometric system integrates two or more biometric samples of an individual which are collectively gathered and fused those biometric identifies into a single image. The term multi-biometrics denotes the fusion of different types of information (Anwar et al.2009) (e.g., fingerprint and face of the same person, or fingerprints from two different fingers of a person).

The fused biometrics is a completely new breed of technology. In the real world, some commonly used objects such as the cell phone equipped with a camera might be easier to combine the face and voice traits of a user, similarly, in a biometric based ATM (Automatic Teller Machine) application which is capable of capturing the fingerprint and face traits of the user. An information fusion strategy ranges from simple Boolean conjunction to sophisticated statistical modeling. Multibiometric systems can address the non-universality problem and reduce the FTER (False True Error Rate) and FTCR (False True Correction Rate). For example, if a person cannot be enrolled in a finger print system due to worn-out ridge details, he can still be identified using other biometric traits like face or iris.

Many developed countries implemented multi-biometric system, whereas developing countries like India also introduces unique identity by launching Aadhaar card. Unique identification Authority of India project is known as "AADHAAR" (http://uidai.gov.in). Aadhaar is a unique 12 digit numbers which is provided to every resident of India. The 12 digit number will contain all basic demographic and bio-metric information about the owner like photograph, ten finger prints and Iris scan in a central database of the individuals http://en.wikipedia.org.. UID card is easily verifiable. Aadhaar will become single source of identity. The earlier security methods enforced by us finding lot of loopholes and able to make proxy representation. These loop holes are easily eliminated by using Aadhaar card. Aadhaar card produces genuine representation for any human. As per security wise the generation of security classified into First, Second and Third generations.

1st Generation Security – Password, Digital signatures, DES and ADES.
2nd Generation Security – Any single enrollment of bio-metrics systems.
3rd Generation Security – Multiple enrollments of biometrics for more authentications.

The multi-biometric system which can be classified into one of the following six categories:(I)Multi-sensor,(II)Multi-algorithm,(III)Multi-instance,(IV)Multi-sample, (V)Multi-modal and (VI) Hybrid (seeFig.2).

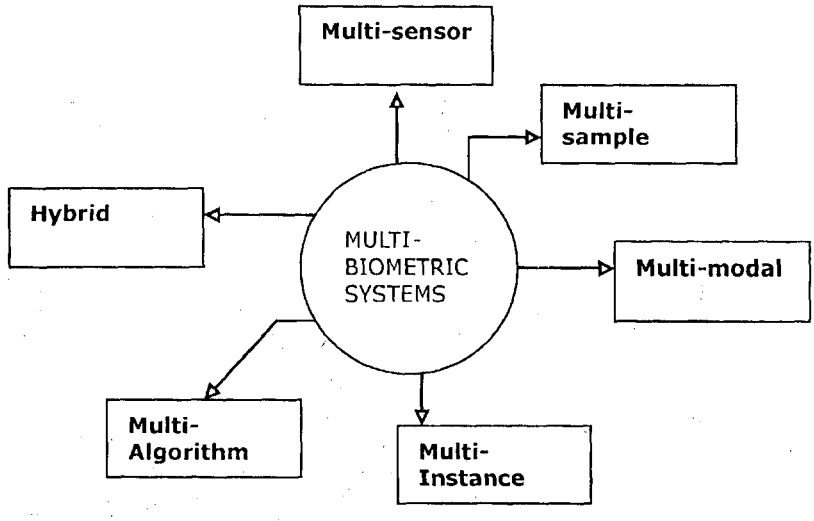

Fig.2: Sources of information for Bio-metric fusion.

- Multi-sensor: More than one sensor components are being used for capturing single characteristic of the Individual. (e.g., a face recognition system may organize with multiple 2D cameras to acquire the face image of a person)

- Multi-sample: A single sensor may attempt to capture more than on samples of the same biometric trait in order to trace the variations that can occur in the trait, or to obtain a more complete representation of the underlying trait. (Ross 2007)

- Multi-modal: The combination of Speech plus Iris actions of a user. Multiple instances, multiple sensors and multiple algorithms to be followed.

- Multi-Instance: In a facial approach, the person supposed to take different view of poses like face (Right), Face (Left) and Face (frontal).Multiple instance of same body traits. Whereas single sensor and single algorithm try to execute the operations.

- Multi-algorithm: In multi-algorithmic systems, identifiers of the same type (such as fingerprints) are processed by using various algorithms. For example, the same fingerprint image is analyzed using minutiae and pattern algorithms. The key target of multi-algorithmic systems is to increase identification reliability.

- Hybrid: Which may be combination all the above and any of the above with Two (or) more.

Table 1: Illustrates the security contents of Non-biometric, Uni-biometric and Multi-biometric system.

Characteristic Information	1st Generation security (Non-Biometric)	2nd Generation security (Uni-Biometric)	3rd Generation security (Multi-biometric)
(i) Focus on security	Less Security	Moderate Security	High Security
(ii) Focus on sensor	Less action	Moderate (Uni sensor)	Higher action (Multi Sensor)
(iii) Validity	Specific Period	Moderate Validity	Life time validity
(iv) Scope of Authentication	Less	Relatively more	Highly enforced
(v) Enrollment	Non-biometric	Mono	Multiple
(vi) Equipment Cost	Less	Relatively high	Very high
(vii) Result activity	Less Precision	Moderate Precision	High Precision
(viii) Database Storage	Less Space	Moderate Space	High memory space required
(ix) Imposter and spoof attack	High Possiblity	Less Possibility	Very less Possibility
(x) Time Frame Enrollment	Minimal	Moderate	High

Comparative study of Uni-biometric / Multi-biometric systems:

The Simple Uni-biometric and Multibiometrics system offers four important components to authorize and identify a person:

(1) Sensor module which acquires the biometric data of an individual. (Ross and Jain 2003).

(2) Feature extraction module in which the acquired data is processed to Extract feature values. (Ross and Jain 2003)

(3) Matching module in which the feature values are compared against those in the template by generating a matching score. (Ross and Jain 2003).

(4) Decision-making module in which the users identity is established or a claimed Identity is either accepted or rejected based on the matching score generated in the matching module (Ross and Jain 2003).

The biometric-based authentication system available in two forms either in the form of Uni- biometric/multi-biometric which follows standard procedure such as

(1) Enrollment (2) verification and (3) validation.

(1) In the Enrollment mode a user's biometric data is acquired using a biometric reader and stored in a database. The stored template is labeled with a user identity. (e.g., name, identification number, etc.) to facilitate authentication. Enrollment involves a copy of a person's biometric feature being taken, converted into a digital format and stored on an electronic database. (AlMahafzah and AlRwashdeh 2012).

(2) In the authentication mode, a user biometric data is once again acquired and the System uses this to either identify who the user is, or verify the claimed identity of the user. While identification involves comparing the acquired biometric Information against templates corresponding to all users in the database, Verification involves comparison with only those templates corresponding to the Claimed identity. Thus, identification and verification are two distinct problems having their own inherent complexities.

(3) Validation: After authentication process, Individual trait of the human is verified to authorize and check whether any imposter and forgery representation carried out in the earlier phases. In terms of computing power, the difference between verification and identification is important: comparing the fingerprint entered by the user with the reference fingerprint (verification) is a simple task. Matching a fingerprint with all those contained in a database of thousands or even millions (identification) requires considerable computer grunt. In most commercial applications of biometrics, the aim is to verify the identity of the user

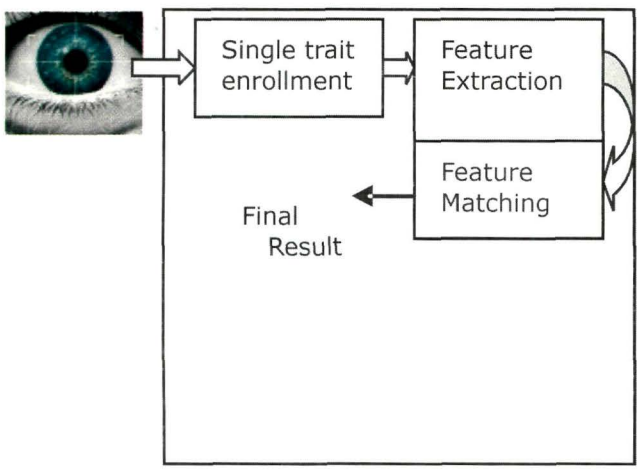

Fig. 3: Singlebiometric Systems

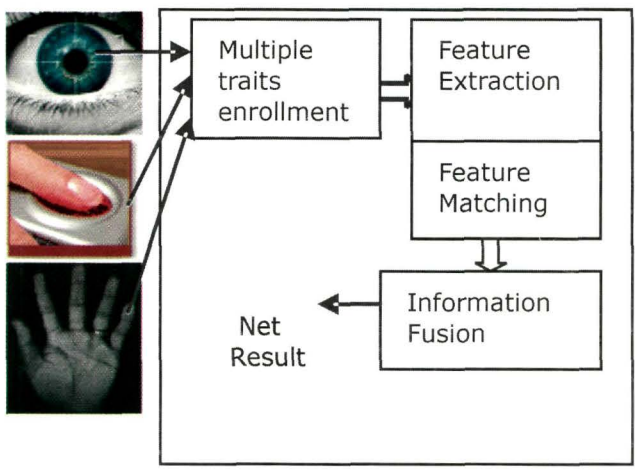

Fig.4: Multibiometric Systems

CONCLUSION

Multibiometrics seems to be more vital area to authenticate the individual, because in this case many traits of humans are captured, even if one case of capturing fails whereas another trait attempts to resolve the problem.Multibiometric systems can offer substantial improvement in the matching accuracy to identify the individual. Which, Reduced FAR (False Acceptance Rate) and FRR (False Rejection Rate) and hence capacity of identification system is highly improved rather than traditional methods. Multibiometrics not only used to identify a person but also used to authenticate the individual. Even though, Multibiometrics addressed to solve the problem of person identity it lacks to removes the nosing and spoof attacks for this many researchers still try to resolve the problem. In real world application, many countries are interested to implement Multibiometrics for identifying the individual while navigating from one country to another and in banking the safety locker maintenance. Definitely, in near future every country may try to adopt Multibiometrics for identifying and authorizing a person.

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EFFICACY OF SEPHADEX GEL FILTRATION ON FROZEN SEMEN QUALITY OF CATTLE ON DIFFERENT STORAGE SYSTEMS

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Abstract

Evaluation of frozen semen at different field level storage points reveals the deterioration of cryo-preserved semen straws used in artificial insemination programme. A total of 4605 semen samples from 15 bulls, maintained under farm condition collected during September, 2005 to March, 2008 at the Frozen Semen Bull Station, Salboni, West Bengal, India for artificial insemination (A I) programme in different district of West Bengal were analyzed for the quantum of deterioration at field level storage points after the Sephadex gel filtration of semen.. The semen traits at different storage points revealed a relative significant (P<0.02) reduction at district semen bank (DSB) and artificial insemination centre (AIC) over regional semen bank (RSB) in sperm motility by 6.98 and 14.22 percent; Intact acrosome by 7.05 and 15.47 percent; hypo-osmotic swelling (HOS) positive by 5.27 and 11.09 percent. In event of cervical mucus penetration capacity there was a reduction of 24.93 % at AIC over RSB. . The Frozen semen straws filtered through Sephadex G-100 column evidenced a significant (P<0.01) improvement over control even stored at Artificial Insemination Centre by 15.25 percent in Post thaw motility; by 15.97 percent in acrosome integrity and by 14.19 percent in hypo-osmotic swelling test.

Keywords: *Cryo-preserved semen, Acrosome integrity, HOS response, Artificial insemination Centre (AIC), District Semen Bank (DSB), Regional Semen Bank (RSB).*

INTRODUCTION

Accurate semen analysis and maintenance of quality of frozen semen are critical components of any assisted reproductive technology. The semen characteristics are the major factors that influence conception rate in cattle and therefore, a determinant of efficiency of reproduction. Although Artificial insemination (AI) using frozen semen emerged 50 years back, fertility rate with A I technology is less and unpredictable. The use of sub fertile or infertile semen can have devastating consequences in the breeding up-gradation programme. Hence, diagnosis and keeping of fertility potential of a semen sample is essential both at the frozen semen laboratory as well as at field level A I centers for high reproductive efficiency and thus productivity. After the production of frozen semen (F S) straw, it reaches to the Gram Panchayet (G P) level A I center through Regional Semen Bank, District Semen Bank and Block level Semen Bank.

The presence of dead, damaged and abnormal sperms in semen has toxic and adverse effects on companion cells on account of peroxidase and proteolytic enzymes released during freezing or storage from such undesirable sperms. Such cell if reduced by some techniques would prolong the life span and fertility of that semen. This is particularly of immense value in maximizing use of genetically superior Sires, donating semen of poor quality and freezability.

The mechanism of separation of immotile, dead and abnormal spermatozoa was suggested by Graham *et al.* (1976), who mentioned that filtration of spermatozoa on sephadex column appears to be physico-chemical reaction with sephadex particles providing a barrier, allowing these types of spermatozoa to agglomerate. In natural mating, cervical mucus differentially selects motile spermatozoa and acts as a barrier to immotile ones (Saacke, 1984). This cervical selection is by-passed in artificial insemination. Methods of separation of motile, normal, or live from immotile, abnormal, or dead ones are more important in the artificial insemination process.

Graham and Graham (1990) found that filtration of bovine semen with high percentage of abnormal spermatozoa resulted in higher recovery rate of motile and normal spermatozoa. Anzar and Graham (1993) reported that Sephadex column improved all the characteristics of spermatozoa involving motility and viability (P<0.01), regardless of their quantity in the column (P > 0.05). Januskauskas *et al.* (2005) reported that filtration through

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sephadex significantly reduced the concentration of recovered spermatozoa ($P<0.01$), but improved semen quality, reducing the number of spermatozoa with various form of morphological defects. They concluded that filtration effectively separates weaken or abnormal spermatozoa in pre-freezing semen samples and therefore the procedure could be recommended to improve post-thaw sperm viability of selected, fertile sires.

The present study was conducted to study the improvement of semen quality with the Sephadex gel filtration of semen before the cryo-preservation process is initiated and distribution of frozen semen straw to the field level storage points like Regional semen bank, District semen bank and Artificial Insemination centre.

MATERIAL AND METHODS

Time and place of study : The study was undertaken at 'Frozen Semen Bull Station' of Composite State Animal Husbandry Farm, Salboni, Dist .-West Midnapore, West Bengal, India under the management of Paschim Bango Go Sampad Bikash Sanstha (ISO 9001:2000, HACCP). The whole study covers the period from September, 2005 to March,, 2008. Four Jersey, four cross bred Jersey (50%), three Sahiwal and four Gir bulls were used in this study. These animals were regular herd sires in Frozen Semen Bull Station (FSBS), Salboni and ranged in age from three to seven years.

Animals and data used: The Bulls were housed in individual 10 X 12 feet stalls and had access at will to 12 X 40 feet extended pen. The Bulls are placed under compulsory exercise with the Bull exerciser situated with in the Farm. The animals had no access to pasture and were maintained on Bull Concentrate feed ('Epic' brand of W.B Dairy and Poultry development Corporation, Salboni plant) at the rate of 3 kg to 5 kg per day per animal depending upon the body weight. Chaffed green fodder and paddy straw at 3:1 ration are included in the ration at the rate of 20 kg to 30 kg daily per animal according to the body weight. 30 gms of mineral mixture are also added with the daily ration for each animal. All the bulls were kept under identical condition of management, feeding (seasonal fodder) and watering.

Semen collection, evaluation and preservation: Semen was collected by artificial vagina (A V) method from every bull twice in a week. Artificial Vagina was prepared appropriately having proper temperature (40-44°C), pressure and softness. A total number of 17 bulls were used for collection of semen during the period of study. Immediately after collection the semen samples were placed in a beaker containing lukewarm water (37° C) and were examined for different semen characteristics like volume, Sperm concentration and Initial motility. Slurries (Graham *et al.*,1976) of Sephadex G-100 (3.3 % w/v) were prepared in 3- 5 trisodium citrate dihydrade buffer (ph 6.8). The slurries were allowed to swell at least for 4 (four) hours at room temperature and then stored in refrigerator at 5°C for further use (Heuer and Tahir, 1982). Sephadex G-100 (100 gm powdered pack was procured from Pharmacia fine chemical, Upsala, Sweden through Sigma Chemical Company, New Delhi.

The 0.6 ml slurries of Sephadex were then pipetted by means of hand operated dip lip pipette in to the 5 ml Dispo-Van syringe (internal diameter 1.5 cm) placed with in graduated conical glass tube collection vessels , arranged in the test tube rack (Chauhan *et al.*, 1993). The nozel of the syringe were firmly plugged with a thin uniform layer of borosilicate glass-wool(3-4 mg) packed at the bottom of the syringes with the help of respective plungers, to retain the sephadex jelly. The rack was then kept in water-bath at 37°C for 30 minutes prior to and during filtration. Before the use, each filter bed was wetted with 2-3 drop of Tris-buffer. As only one grade of sephadex i.e SG-100 was used for the study the half of the ejaculates (neat semen) were gently put into each Dispo-Van tube containing slurry, by allowing it to run smoothly along the wall and half of each ejaculates were processed further with out filtration as control. The filtration of semen was done keeping the glass tube rack in the water bath at 37°C. The complete filtration process took about 2-3 minutes in the entire column. The controls as well as filtrates of sephadex column were then examined for sperm concentration/ml ($X10^6$) and percent initial motility as per the previous procedure of this study. eighty (80) collections (ejaculates) from fifteen (15) bulls of four breeds were considered for this filtration method. At the end of filtration process the samples were diluted using Tris Fructose Yolk Glycerol diluents (TFYG) with the standard composition (for 1000 ml of diluents). Tris 24.22 gms, Citric Acid 13.60 gms, D-Fructose 10.00gms, Triple distilled water (Millipore) 736 ml, Glycerol 64 ml, Egg Yolk 200 ml, Benzyl Penicillin 10 lakh unit and Streptomycin 1.00 gm.

Dilution of neat semen using the diluents were carried out so that the 0.25 ml of diluted semen should contain at least 20 million of spermatozoa and pH should remain within the range of 6.8 to 7.0. After the dilution is

completed, the semen were filled in Imv make French type 0.25 ml straw with the help of automatic computer assisted filling, sealing and printing equipment (Imv make IS- 3) . Sealed straws were then kept in the cold cabinet to cool down the straws up to 4°C for four hours as equilibration period. After the period of equilibration is over the straws were put in to the Bio-freezer for freezing the straws up to 140°C in 9 minutes and finally up to 196°C. The frozen Straws were then kept in the liquid nitrogen for preservation at 196°C. Post thawed semen samples (control & filtrate of SG-100) were evaluated under phase-contrast microscope for post thaw motility, acrosome integrity and HOS response of spermatozoa.

Post Thaw motility: The straw containing frozen Semen was thawed in a water bath at 37°C - 38°C for 10 – 20 seconds. The sperm motility was always evaluated at 37°C using Phase-Contrast Microscope at 400 X magnification. Post thaw motility with more than 50 % progressive motile spermatozoa is considered otherwise the batches are discarded.

Acrosome integrity Test: A thin smear of frozen semen on glass slide was air dried and immersed in 5% formaldehyde for 30 minutes at 37°C. Washing the slide in water and dried in air it is then immersed in Giemsa stain for 3 hours at 37°C. [Giemsa stain (3ml) was mixed with 2 ml of Sorenson phosphate buffer at pH 7 with 45 ml of distilled water]. After 3 hours the slide is washed in water and dried in air. It was examined under DIC microscope with oil immersion objectives (Watson, 1975). A total of 100 spermatozoa per sample were counted to classify the acrosome integrity at 'intact', 'altered' or completely loss. The sample containing more than 30 – 40 % of acrosomal alteration are not accepted.

Hypo-Osmotic Swelling (HOST) Test: Hypo osmotic swelling (HOS) medium is prepared with equal volume of sodium citrate solution (0.367 gm of sodium citrate in 50 ml of triple glass distilled water) and fructose solution (0.675 gm of Fructose in 50 ml of triple glass distilled water). 0.1 ml of frozen thawed semen was mixed with one ml of HOS medium and incubated the mixture at 37°C for 30 minutes. One drop of incubated semen-HOS media mixture was placed on glass slide under coverslide and examined with the help of DIC microscope for the detection of tail curling of spermatozoa (Jayendram *et al.*, 1984). Good semen sample containing about 60 – 70 % of spermatozoa with tail curled in frozen thawed semen was accepted.

$$\text{Percentage of Spermatozoa with tail curling} = \frac{\text{no. of tail curled sperm X100}}{\text{total no sperm counted}}$$

After the production with Sephadex filtration, the frozen semen straws both filtered (SG-100) and unfiltered (control) were stored at laboratory in liquid nitrogen for one month before distribution to Regional semen bank(RSB), District semen bank (DSB) and Artificial insemination centre (AIC) at village level. Out of 18120 frozen semen straw (both control and SG-100) only 2000 of SG-100 and 2000 of Control marked straws were distributed to field level storage points starting from Regional semen bank (RSB) at per normal distribution process adopted in the field. After the expiry of three months from the date of distribution only 320 (three hundred twenty) no. of frozen semen straws (both of control and SG-100) were withdrawn from Regional semen bank (RSB) and Artificial insemination centre (AIC) at 20 (twenty) occasions on the availability and matching of the Bull no. and date of production at storage points. On every occasion of withdrawal of F.S.Straw from different storage points, the evaluation for post thaw motility, Acrosome integrity and Hypo-osmotic swelling test were carried out at per same protocol described earlier (Table-1).

Collected data were analyzed using "MSTAT" computer program to compute analysis of variance (ANOVA) according to Steel and Torrie (1984). Chi-Square test was performed to identify significant difference between control and treatment group (Snedecor and Cochran, 1980).

RESULTS

The evaluation of frozen semen straws, produced after Sephadex filtration and distributed in the field level storage points was also carried out to predict the status of quality in comparison to unfiltered frozen semen straws. The results along with statistical analysis are summarized in table-1, table-2 and table-3.

The overall means of different spermatozoa traits, irrespective of breed, evaluated in the Frozen semen straws, filtered through Sephadex G-100, taken from Laboratory (LAB), Regional Semen Bank (RSB) and A.I Centre (AIC) were 78.93±0.13, 74.87±0.10 and 66.50±0.54 percent respectively for Post thaw motility; 93.85±0.08, 89.76±0.14 and 85.35±0.24 percent for Acrosomal Integrity and 73.19±0.20, 68.35±0.19 and 62.16±0.18 percent for HOS positive semen whereas

Table -1. Mean (±SE) Post thaw motility (%), Intact Acrosome (%) and HOS positive (%) of Frozen semen samples of 15 Bulls before (control) and after (SG-100)Sephadex filtration including evaluation after distribution at different field level storage point like Regional Semen Bank (RSB) Artificial Insemination Centre AIC).

Bull No	Breed	Post Thaw motility%				Intact Acrosome %				H O S T POSITIVE %			
		R S B Control	SG-100	A I Centre Control	SG-100	R S B Control	SG-100	A I Centre Control	SG-100	R S B Control	SG-100	A I Centre Control	SG-100
J-3954(1116) (n=20)	Jersey	62.00±1.22	75.00±1.58	53.00±1.22	68.00±2.54	79.40±0.40	91.80±0.37	72.00±0.44	86.80±0.66	58.40±0.81	71.00±0.44	50.00±0.71	63.80±0.58
J-3939(1115) (n=20)	Jersey	59.00±1.87	77.00±2.00	51.00±1.00	71.00±1.87	79.40±0.60	90.80±0.37	71.60±0.67	86.00±0.54	56.40±0.67	68.40±0.51	48.00±1.09	61.60±0.51
J-3910(1114) (n=20)	Jersey	59.00±1.87	75.00±1.58	50.00±1.58	70.00±1.58	79.80±0.66	91.00±0.71	72.60±0.81	83.80±0.86	57.00±0.55	67.20±0.80	47.80±0.81	59.80±0.37
SJ-380(1103) (n=20)	Jersey	56.00±1.87	76.00±1.86	48.00±1.22	70.00±2.23	81.00±0.31	90.80±0.37	72.60±1.07	84.80±0.37	58.80±0.58	70.00±0.55	49.00±0.71	61.60±0.51
JX-265(2104) (n=20)	C B J	63.00±1.22	76.00±1.00	51.00±1.00	63.00±4.35	76.20±0.58	90.00±0.84	66.00±0.83	84.20±0.86	55.60±0.93	67.00±0.70	49.00±0.45	61.80±0.73
JX-325(2107) (n=20)	C B J	62.00±1.22	73.00±2.55	52.00±1.22	53.00±1.22	77.20±1.16	87.80±0.86	70.00±2.02	81.20±1.02	56.00±1.52	66.40±0.93	48.60±1.12	60.60±0.87
JX-313(2106) (n=20)	C B J	63.00±1.22	75.00±1.58	53.00±1.22	54.00±1.87	76.80±0.86	88.20±0.86	68.20±2.73	82.80±0.86	57.40±0.93	68.80±0.86	50.00±0.71	62.20±0.58
JX-115(2101) (n=20)	C B J	63.00±1.22	74.00±1.87	53.00±1.22	67.00±2.55	76.40±0.51	88.00±1.00	68.80±1.20	81.80±1.35	55.80±0.58	68.20±0.86	47.60±0.51	63.20±0.58
CMT-229(4106) (n=28)	SAHIWAL	60.71±1.70	75.71±1.30	51.42±0.92	69.28±1.30	78.14±0.51	90.29±0.56	72.00±0.69	89.43±0.48	55.71±0.61	65.86±0.74	49.86±0.59	65.43±0.92
CMT-193(4105) (n=24)	SAHIWAL	60.00±2.24	74.17±1.53	51.67±1.05	67.50±1.12	78.67±1.05	89.17±0.75	71.33±0.49	86.50±1.41	57.00±0.58	67.17±0.40	49.67±0.42	66.00±0.45
CMT-83(4103) (n=28)	SAHIWAL	61.43±1.42	76.43±0.92	51.43±0.92	69.28±0.71	76.57±0.78	87.43±0.84	68.57±0.68	87.29±0.81	54.86±0.74	66.86±0.80	48.57±0.53	62.14±0.67
G-9610(6102) (n=20)	G I R	64.00±1.00	74.00±1.00	53.00±1.22	68.00±1.23	80.00±0.32	89.80±0.58	66.20±0.57	85.20±0.66	57.40±0.67	69.80±0.97	48.20±0.86	64.40±0.60
G-9685(6108) (n=20)	G I R	62.00±1.22	72.00±1.23	51.00±1.00	67.00±2.00	79.40±0.75	90.20±0.66	67.20±0.58	85.60±0.51	55.60±0.51	69.20±0.58	44.60±0.87	64.20±0.49
G-9653(6106) (n=20)	G I R	62.00±2.00	73.00±1.22	51.00±1.87	68.00±1.22	79.40±0.81	90.40±0.87	66.40±0.68	85.40±0.93	56.80±0.49	70.60±0.75	43.60±0.81	56.80±0.86
G-1047(6114) (n=20)	G I R	58.00±1.22	76.00±1.00	48.00±2.00	70.00±1.58	80.40±0.51	91.60±0.51	66.20±0.80	86.80±0.73	56.20±0.86	71.40±0.68	43.80±1.39	56.80±0.73
Over All (n=320)		61.06±0.16	74.87±0.10	51.25±0.09	66.50±0.54	78.52±0.18	89.76±0.14	69.39±0.28	85.35±0.24	56.54±0.89	68.35±0.19	47.97±0.22	62.16±0.18

CBJ- Cross Breed Jersey (50%), n = no of semen samples.

Table 2: Mean (±SE) Post thaw motility (%), Intact Acrosome (%) and HOS positive (%) of Frozen semen samples of different breeds of bulls before (control) and after (SG-100) Sephadex filtration including evaluation after distribution at different field level storage point like Regional Semen Bank (RSB) Artificial Insemination Centre (AIC) in comparison to evaluation at Frozen Semen Laboratory (LAB).

	Breed	Treatment	Post Thaw motility%			ACROSOMAL INTRIGITY			H O S T POSITIVE		
			LAB	R S B	A I Centre	LAB	R S B	A I Centre	LAB	R S B	A I Centre
1	**JERSEY** (n=80)	Control	68.75±0.88	59.25±0.91	50.50±0.72	84.05±0.26	79.89±0.28	72.20±0.37	63.10±0.37	57.65±0.38	48.70±0.43
		SG-100	80.25±0.85	75.75±0.83	69.75±0.99	94.75±0.23	91.11±0.24	85.35±0.39	74.15±0.38	69.15±0.43	61.70±0.39
2	**CBJ** (n=80)	Control	68.25±0.65	62.75±0.57	52.25±0.57	83.20±0.34	76.65±0.38	68.25±0.91	62.65±0.46	56.20±0.51	48.80±0.38
		SG-100	79.5±0.72	74.50±0.88	59.25±1.86	94.10±0.29	88.50±0.46	82.50±0.54	73.60±0.53	67.60±0.44	61.95±0.39
3	**SAHIWAL** (n=80)	Control	64.50±0.88	60.75±0.98	51.50±0.53	82.91±0.38	77.75±0.47	70.60±0.49	60.90±0.37	55.80±0.41	49.35±0.32
		SG-100	77.75±0.85	75.50±0.72	68.75±0.62	92.95±0.48	88.95±0.48	87.80±0.58	70.65±0.33	66.40±0.32	64.45±0.56
4	**GIR** (n=80)	Control	65.25±0.67	61.50±0.82	50.75±0.83	83.80±0.31	79.80±0.30	66.50±0.32	61.45±0.37	56.50±0.34	45.05±0.63
		SG-100	78.25±0.75	73.75±0.62	68.25±0.75	93.60±0.36	90.50±0.34	85.75±0.36	74.35±0.42	70.25±0.39	60.55±0.92
	Overall (n=320)	Control	66.68±0.24	61.06±0.16	51.25±0.09	83.48±0.06	78.52±0.18	69.38±0.28	62.03±0.11	56.54±0.89	47.97±0.22
		SG-100	78.93±0.13	74.87±0.1.	66.50±0.54	93.85±0.08	89.76±0.14	85.35±0.24	73.19±0.20	68.35±0.19	62.16±0.18

CBJ- Cross Breed Jersey (50%), n = no of semen samples.

the above values in unfiltered (control) frozen semen straw at LAB, RSB and AIC were 66.68±0.24, 61.06±0.16 and 51.25±0.09 percent respectively for Post thaw motility; 83.48±0.06, 78.52±0.18 and 69.38±0.28 percent for Acrosomal Integrity and 62.03±0.11, 56.54±0.89 and 47.97.16±0.22 percent for HOS positive. The Frozen semen straws filtered through Sephadex G-100 column evidenced a significant (P<0.01) improvement over control even stored at Artificial Insemination Centre by 15.25 percent in Post thaw motility; by 15.97 percent in Acrosome integrity and by 14.19 percent in Hypo-Osmotic swelling test (Table-1,2,3).

DISCUSSION

The observations on the semen characteristics of Sephadex filtered frozen semen samples at various field level storage points shows a significant (P<0.01) improvement against the unfiltered frozen semen which may evolve a new dimension in the frozen semen biotechnology. In this study it has been observed that post thaw motility in unfiltered straws remains 66.68±0.24 percent at laboratory but it is reduced to 51.25±0.09 percent while evaluated from the straw of A I centre which stands a reduction of 15.43% of post thaw motility. It is very much convincing that the sephadex filtered frozen semen retains the post thaw motility up to 66.50±0.54 percent at A I centre which is above 15.25% of the unfiltered frozen semen. In acrosome integrity test and hypo-osmotic swelling test the improvement was 15.97% and 14.19% respectively in the filtered semen evaluated from the frozen semen straws withdrawn from A I centre. The retention of the semen characteristics at the field level storage points certainly unfastens the problem of decreased conception rate through artificial insemination at field level. The fertility potential of the spermatozoa lies completely with these characteristics like post thaw motility, acrosome integrity and HOS response need to be restored to prevent deterioration of bio-physiological status of spermatozoa.

In natural mating, cervical mucus differentially selects motile spermatozoa and acts as a barrier to immotile ones. This cervical selection is by-passed in artificial insemination. Methods of separation of motile, normal, or live from immotile, abnormal, or dead ones are of more important in the artificial insemination process (Saacke, 1984). Filtration effectively separates weaken or abnormal spermatozoa in pre-freezing semen samples and therefore the procedure could be recommended to improve post-thaw sperm viability (Januskauskas *et al.*, 2005). These findings have the positive indications to carry out the present study for the improvement of frozen semen quality to increase the conception rate of pregnancy through Artificial Insemination at field level.

There is a tremendous scope of improving the present

Table 3: Chi-Square test value shows the effect of Sephadex filtration on frozen semen at different field level storage point – Regional Semen Bank (RSB) and Artificial Insemination Centre (AIC).

Source Variances	Degree of Freedom	Chi-square test Value	Significant level	Probability
Breed- Jersey : Control vs Sephadex filtration	1	25.059	0.0007	P<0.01
C B J : Control vs Sephadex filtration	1	17.421	0.0149	P<0.02
Sahiwal : Control vs Sephadex filtration	1	25.463	0.0006	P<0.01
G I R : Control vs Sephadex filtration	1	28.684	0.0001	P<0.01
Over all : Control vs Sephadex filtration	1	23.376	0.0016	P<0.01
Post Thaw Motility : Laboratory vs A I C	1	23.289	0.0015	P<0.01
Laboratory vs R S B	1	3.080	0.8774	P>0.05 NS
R S B vs A I C	1	10.947	0.1409	P>0.05 NS
Acrosome Integrity : Laboratory vs A I C	1	13.060	0.0706	P>0.05 NS
Laboratory vs R S B	1	1.980	0.9827	P>0.05 NS
R S B vs A I C	1	5.570	0.4279	P>0.05 NS
Hypo-osmotic Swelling : Laboratory vs A I C	1	19.955	0.0057	P<0.01
Laboratory vs R S B	1	2.585	0.9205	P>0.05 NS
R S B vs A I C	1	10.033	0.1867	P>0.05 NS

situation through crossbreeding or grading up of the non-descript as well as indigenous low producing cattle population , preferably with optimum and steady conception rate through artificial insemination with quality frozen semen at field level A I Centers. The outcomes of the work have a commendable role for a successful artificial insemination programme to improve the quantum of deterioration in semen characteristics at the different field level storage points like Regional semen bank, District semen bank and Artificial Insemination centre The results of the present investigation would be a point for the advancement of artificial insemination technology.

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DEVELOPMENT AND CHARACTERIZATION OF NANOPARTICLES CONTAINING ZIDOVUDINE

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Abstract

Present study was conducted to overcome the pharmacokinetic limitations of commonly preferred anti-HIV drug, zidovudine with the implication of nanotechnology. Poly (lactide-co-glycolide) (PLGA) nanoparticles encapsulating zidovudine (AZT) were developed by multiple emulsion solvent evaporation technique and characterization was done with respect to sizing, zeta potential, shape (Scanning Electron Micrograph), Fourier Transform-Infrared spectroscopy and X-ray Diffraction (XRD) patterns. The PLGA particles loaded with zidovudine were found to be stable and in nano-range. FTIR images indicated drug-polymer interactions. Absence of any sharp diffraction peaks in the XRD patterns of encapsulated drugs indicated a complete amorphization of drugs in nanoparticles. We found out that PLGA nanoparticles loaded with zidovudine holds great prospective for extended *in vivo* research in higher animals.

Keywords: *zidovudine, PLGA Nanoparticles*

INTRODUCTION

Human immunodeficiency virus (HIV) is a retrovirus that causes acquired immunodeficiency syndrome (AIDS). An estimated 36 million people are infected with human immunodeficiency type-1 (HIV-1) worldwide (Zarocostas 2007). Current international guidelines now recommend early initiation of Highly Active Antiretroviral Therapy (HAART) for symptomatic individuals and asymptomatic individuals with low CD4 cell count levels (i.e. <250 cells/ il), but also for asymptomatic individuals with CD4 cell count <350 cells/il (Hull *et al*, 2009 and http:// www.aidsinfo.nih.gov/ContentFiles/Adultand Adolescent GL.pdf. The recommended therapy against HIV infection mainly consists of a non-nucleoside reverse transcriptase inhibitor (NNRTI) or a protease inhibitor boosted with low dose ritonavir, each combined with two nucleoside reverse transcriptase inhibitor (NRTI). Most of the times, the choice between these classes of drugs has been found to be based on the patient's profile and upon toxicity or treatment failure, the therapy is altered accordingly (Scott *et al.*, 2006). Zidovudine (AZT), a nucleoside analog reverse-transcriptase inhibitor (NRTI) and an analog of thymidine is the most widely used drug to treat AIDS alone and in combination.

Although the antiretroviral therapy has significantly reduced HIV-1 disease morbidity and improved life expectancy but the factors like side effects associated with drugs that lead to non-adherence and non-persistence to HAART, economics of drug treatment, development of resistance and limited global access has prevented world-wide utility of antiretroviral therapy (Destache *et al.*, 2009).

By looking at the present limitations of HAART, it is thoughtful of accepting an alternative strategy, which should reduce the toxicity of the drugs and allows prolonged application intervals of the drugs. With the development of sustained release drug formulation, the outcome and adherence to therapy can be improved which will further lead to reduction in number of times a drug has to be administered resulting in better patient compliance. The therapeutic efficacy of anti-HIV agents is often hampered by poor bioavailability and lack of drug penetration in infected target tissues and cells. Therefore by using different types of nanotechnology-based delivery systems, it is possible to engineer strategies that can improve the therapeutic efficacy in HIV/AIDS by delivering drugs to cellular and anatomical viral reservoirs and thereby increasing residence time at the target site and consequently reducing the frequency of doses. All these factors contribute significantly to keep the patients more highly adherent to therapy. Nanocarriers are also known to facilitate lymphatic transport, delivery across the blood–brain barrier, and efficient internalization in cells by nonspecific or receptor-mediated endocytosis (Semete *et al.* 2008).

Various studies have been carried out in recent times to enhance the bioavailability of anti-HIV drugs by

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employing biodegradable carrier systems to overcome the limitations of conventional therapy. Nanoparticles made out of human serum albumin (HSA-NP) and polyhexylcyanoacrylate (PHCA-NP) loaded AZT and ddC have been used to examine their potential in inhibiting *in vitro* HIV-1 replication (Bender et al, 1994). Liposomes loaded zidovudine (AZT) were developed using thin film hydration technique and the AZT-loaded liposomes showed drug targeting to liver followed by lungs, kidney and spleen (Doijad *et al*, 2009). HPMC microspheres loaded with AZT have been developed by Phalguna *et al*, 2010 by emulsification heat stabilizing method with drug entrapment efficiency of 69%.

These studies depicted that the field of nanotechnology is very fast and promising and researchers should keep on putting more efforts to further explore it. PLGA which has been approved in the year 2000 by Food and Drug Administration for application in drug targeting has been used in the present study (Jain, 2000 and Gref *et al*, 1994). Keeping in view the limitations of conventional chemotherapy of HIV infection, nanotechnology based delivery system for AZT, was formulated in this study.

MATERIALS AND METHODS

Chemicals and Drugs

Poly (DL-lactide-co-glycolide) Resomer 502 was purchased from Boehringer Ingelheim Pharma, Germany; polyvinyl alcohol (87-90% hydrolyzed, average molecular weight 30, 000-70, 000 Da) was purchased from Sigma Chemical Co. (St. Louis, MO, USA). Zidovudine was kindly provided by (G E Healthcare Pvt Ltd. Chandigarh). HPLC grade solvents such as acetonitrile (ACN), methanol and dichloromethane (DCM) were purchased from Rankem Fine Chemicals (New Delhi, India) and Merck Ltd. (Mumbai, India), respectively. All other chemicals and reagents used were of standard analytical grade.

Preparation of anti-HIV drug loaded PLGA nanoparticles

Zidovudine (AZT) loaded PLGA nanoparticles were developed by double emulsion solvent evaporation technique keeping the drug: polymer ratio at 1: 10 (w/w). AZT was dissolved in double distilled water: methanol (4: 1, v/v) and primary emulsion was obtained by pouring this drug solution into DCM containing polymer and homogenized at 23000 rpm for 1-2 min in ice-bath. Further this primary emulsion was poured into 1% polyvinyl alcohol (DCM: 1% PVA in ratio of 1: 2 v/v) and homogenized at 23000 rpm for 3-5 min in ice-bath and secondary emulsion was obtained. The nanoemulsions of AZT so obtained were kept on magnetic stirring overnight for removal of DCM and centrifuged at 21000 rpm for 20 min at 4°C. The pellet so obtained was washed thrice with double distilled water and again centrifuged at 21000 rpm for 10 min at 4°C. The final pellet was suspended in minimum to minimum double distilled water and kept at -80°C for lyophilization. The lyophilized powder was used for characterization of nanoparticles and further experiments.

CHARACTERIZATION

The PLGA nanoparticles were characterized for their size, polydispersity index and zeta potential on Zetasizer 1000 HS (Malvern Instruments, Malvern, U.K.).

Surface morphology was assessed by employing Scanning Electron Microscopy (SEM) (Philips XL 30 scanning microscope, Philips, Netherlands) to nanoparticles loaded with individual anti-HIVdrugs (RTV, ddI and AZT). Lyophilized powder was placed on double stick tape over aluminium stubs to get uniform layer of particles and further coated with a thin layer of colloidal gold applied in a cathodic vaccum evaporator at 40 milliampere current and 50 millitorr pressure for 200 seconds and observed at 20 kV. Nanoparticles from five to seven different SEM fields were measured to determine the mean particles size of nanoparticles.

Fourier Transform-Infrared (FT-IR) analysis of empty nanoparticles, anti-HIV drug zidovudine in free and PLGA nanoparticles encapsulated form was done on Perkin Elmer spectrometer (Perkin Elmer, Boston, MA). The FT-IR spectrums were obtained by mixing the samples to be analyzed with potassium bromide and pressed to obtain pellets which were then scanned in the IR range from 400 to 4000 cm^{-1} with a resolution of 8 cm^{-1}. The FT-IR spectrums were recorded to check drug polymer interactions.

X-ray Diffraction (XRD) analysis of pure drugs and freeze dried drug loaded nanoparticles were exposed to monochromatic CuKá radiation (40 kV, 20 mA) and the diffraction angle 2è was recorded from 3°C to 40 °C with a scanning speed of 0.01°C/sec in the X-ray diffractometer (Brooker D8, Germany). All experiments were performed at room temperature.

The nanoparticles containing drugs were lysed in lysis solution (0.1N NAOH in 5% Sodium dodecyl sulphate) to release the drugs and the percentage drug encapsulation efficiency was determined as:

[Amount of drug (mg) released from nanoparticles/ amount of drug (mg) initially taken to prepare the nanoparticles] × 100

Drug loading capacity was expressed as the amount of drugs (mg) entrapped per gram of the polymer.

High performance liquid chromatography (HPLC)

The drugs were analyzed by HPLC comprising of a dual-piston reciprocating pump, an online de-gasser, a UV-visual dual wavelength detector (each of series 200) and a 600 Series Link Interface for data acquisition/ processing, all from Perkin Elmer Instruments LLC (Shelton, CT, USA). AZT were analyzed by employing a USP gradient program using C18 column (Symmetry ® from Waters; 4.6 x 250 mm; 5ìm particle size) protected by guard column on PerkinElmer HPLC system. The mobile phase consisted of acetate buffer (20mM potassium acetate adjusted to pH 4.60 with 20mM acetic acid) and acetonitrile. Mobile phase A, consisted of acetate buffer: acetonitrile (95: 5, v/v) and mobile phase B, consisted of acetate buffer: acetonitrile (76: 24, v/v). After 10 min 100% mobile phase A, the mobile phase B concentration was increased in 14 min linearly from 0 to 100%. After that, mobile phase A concentration returned to 100% in 2 min. The column was then re-equilibrated for 9 min. The mobile phase flow rate was set at 1.0 ml/min, injection volume was set at 25ìl and UV detection was performed at 260 nm. The approximate retention time for zidovudine was 24.69 min. The analytical sensitivity of the method was found to be 0.015ìg/ml. The percentage plasma recovery was 85.20% for zidovudine (Wissen *et al.*, 2005).

In vitro drug release study

Freeze dried drug loaded nanoparticles were evaluated for *in vitro*drug release inphosphate buffer saline (PBS; pH 7.4), simulated gastric fluid (SGF; 0.2% w/v NaCl, pepsin, 0.7% w/v HCl with pH 1.2) and simulated intestinal fluid (SIF; 0.685g monobasic potassium phosphate, 1% NaOH and 1% pancreatin with pH 7.4) by dialysis membrane method. The dialysis bags (molecular weight cut-off of 12 kDa, Himedia, Mumbai, India) were soaked in double distilled water for 12 h before use. Drug loaded PLGA nanoparticles (20mg) were redispersed in 1ml of PBS, SGF and SIF containing 0.1% w/v Tween 80 and poured in dialysis bags. The bags were suspended in25ml of receiving phase (PBS, SGF or SIF) and placed into a thermostatic shaker maintained at 37°C and 100 rpm. Aliquots of 100il were withdrawn at 0.25, 0.5, 1, 3, 6, 12 and 24 h on the first day followed by sampling at 24 h interval, diluted with methanol and filtered through 0.2ì filters. The medium was replaced with same volume of fresh medium after each aliquoting.

RESULTS

The average size of AZT, ddI and RTV loaded PLGA nanoparticles was found to be 213.05±34.7 nm, 266.10±20.0 nm and 238.9±7.4 nm respectively. The encapsulation efficiency of AZT, ddI and RTV loaded PLGA nanoaprticles were 12.33±2.51% w/w, 7.33±2.51% w/w and 56.25±17.9% w/w at 1% PVA w/v concentration respectively. The nanoparticles exhibited fairly negative zeta potential indicating a stable nanoformulation (Table I). The Scanning electromicrograph images showed that the nanoparticles had smooth surface and were spherical in shape (figure 1a, b & c).

The FTIR images of didanosine and ritonavir showed same peaks of respective free drugs in PLGA encapsulated form too, indicating that these drugs were encapsulated in the PLGA nanoparticles and did not show any drug-polymer interaction (Figure 2A). However, zidovudine loaded PLGA nanoparticles exhibited drug-polymer interaction. The major bands of FTIR spectra for anti-HIV drugs are shown in table II. XRD patterns of

Table I: Physicochemical characterization of PLGA nanoparticles encapsulating anti-HIV drugs.

Parameter	Zidovudine(AZT)
Size(nm)	213.05±34.7
Polydispersity index	0.084±0.03
Drug encapsulation efficiency (%)	12.33 ± 2.51
Drug loading capacity (mg/g polymer)	12.33 ± 2.51
Zeta potential	-7.665±4.8

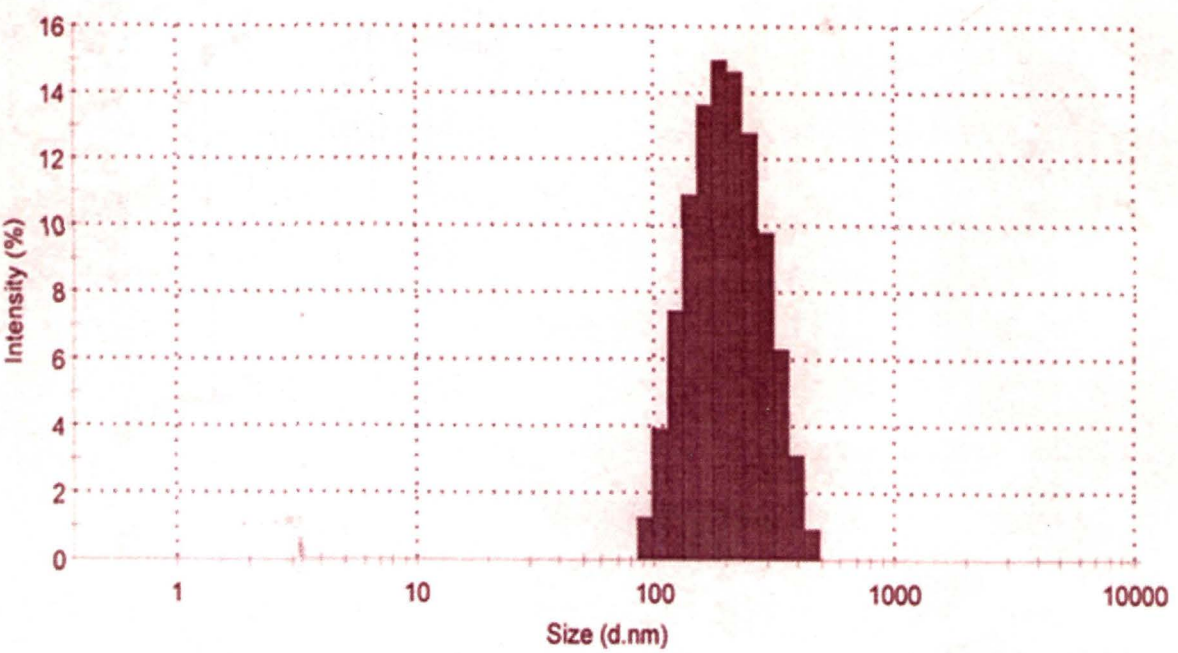


Fig. 1: Particle size distribution of PLGA nanoparticles encapsulating Zidovudine.

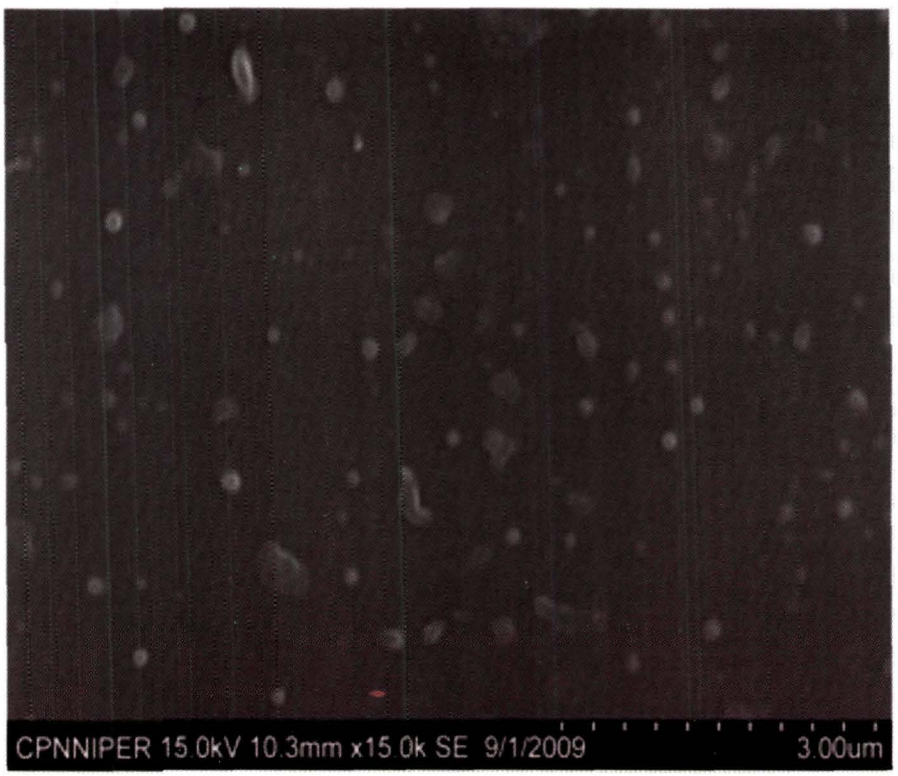


Fig. 2: Scanning electron micrograph of PLGA nanoparticles encapsulating Zidovudine.

Table II: Major bands of FTIR spectra of ritonavir, zidovudine, didanosine, empty PLG nanoparticles and drug loaded PLG nanoparticles.

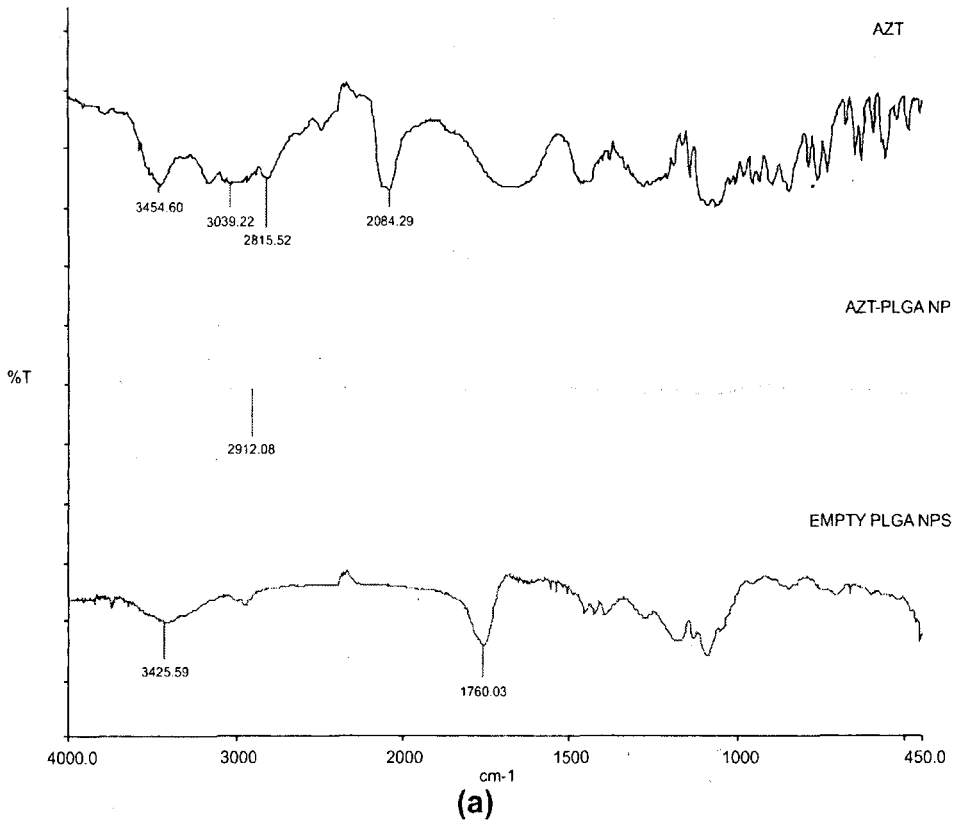
Band No.	AZT	AZT PLGA NP	Empty PLGA NP
1.	3454.60 [O-H stretch (3200-3600 cm^{-1})]	2912.08 [O-H stretch (2500-3300 cm^{-1})]	3425.59 [O-H stretch, H-bonded (3200-3600 cm^{-1})
2.	3039.22 [C-H stretch (3000-3100 cm^{-1})]		1760.03 [C=O stretch (1670-1820 cm^{-1})]
3.	2815.12 [O-H stretch (2500-3300 cm^{-1})]		1426.88 [C=C stretch (1400-1600 cm^{-1})]
4.			

PLGA nanoparticles encapsulating AZT and ddI were characterized by complete absence of sharp diffraction peaks, suggesting a complete amorphization of drugs in nanoparticles upon comparison to free AZT and ddI. However in case of RTV, absence of sharp peaks indicated that drug was in amorphous state in both as intact powder form and PLGA nanoparticle form (Figure 2B).

DISCUSSION AND CONCLUSIONS

HIV is a global epidemic infection. Without any doubt, the present ART has upgraded the quality and survival rates of HIV patients, still in view of various persisiting drawbacks of ART, enhancement of pharmacokinetic parameters with implication of nanotechnology should be the preferred approach. The present work evaluated the sustained release potential of PLGA based nanoparticles for anti-HIV drugs i.e. AZT, ddI and RTV by studying various characteristics and pharmacokinetic parameters. FT-IR analysis measures the selective absorption of light by the vibrational modes of specific chemical bonds in the samples. The empty nanoparticles and anti-retroviral drugs loaded nanoparticles showed same peaks contributed by the functional groups of PLGA. The changes in the bands of functional groups of zidovudine is observed which is probably due to drug-polymer interactions which change the environment of functional groups, causing changes in the position of bands corresponding to these functional groups.

The X-ray diffraction graph of PLGA drug loaded nanoparticles showed absence of sharp peaks, suggesting amorphization of drugs in naoparticles. The presence of numerous small peaks is due to reason that their positions correspond to periodic spacing of atoms in solid state. The sharp diffraction peaks of free drug indicate that drug is in crystalline form. The graph of drug loaded nanoparticles demonstrates almost similar reflection in the diffraction pattern as seen in free drug diffractogram. The appearance of characteristic peaks of drug in drug loaded nanoparticles suggested that drug in nanoparticles is in the crystalline phase. Furthermore the intensity of X-ray diffraction peaks of drug was decreased in drug loaded nanoparticles diffractogram due to presence of less amount of drug in nanoparticles (mg/10mg nanoparticles). In X-ray diffraction, the detection limit of drug depends much on the relative intensity and position of signals campared to that of carrier (PLGA) matrix (as well as stabilizer and other dispersion components). Therefore, the increase and deletion of peak of drug in drug loaded nanoparticles diffractogram were either due to interference of PLGA, residual PVA as impurity or preferred orientation of crystals. It was found that PLGA based drug delivery system is an ideal solution to the



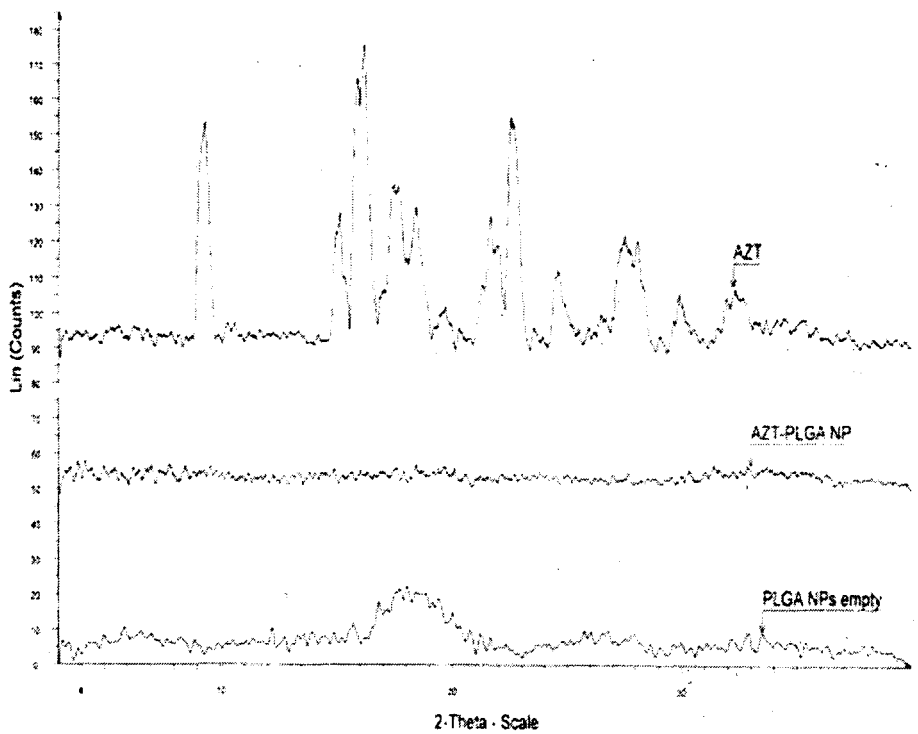


Fig. 3: Fourier Transform-Infrared and X-ray Diffraction images of free zidovudine (AZT), empty and zidovudine loaded PLGA nanoparticles.

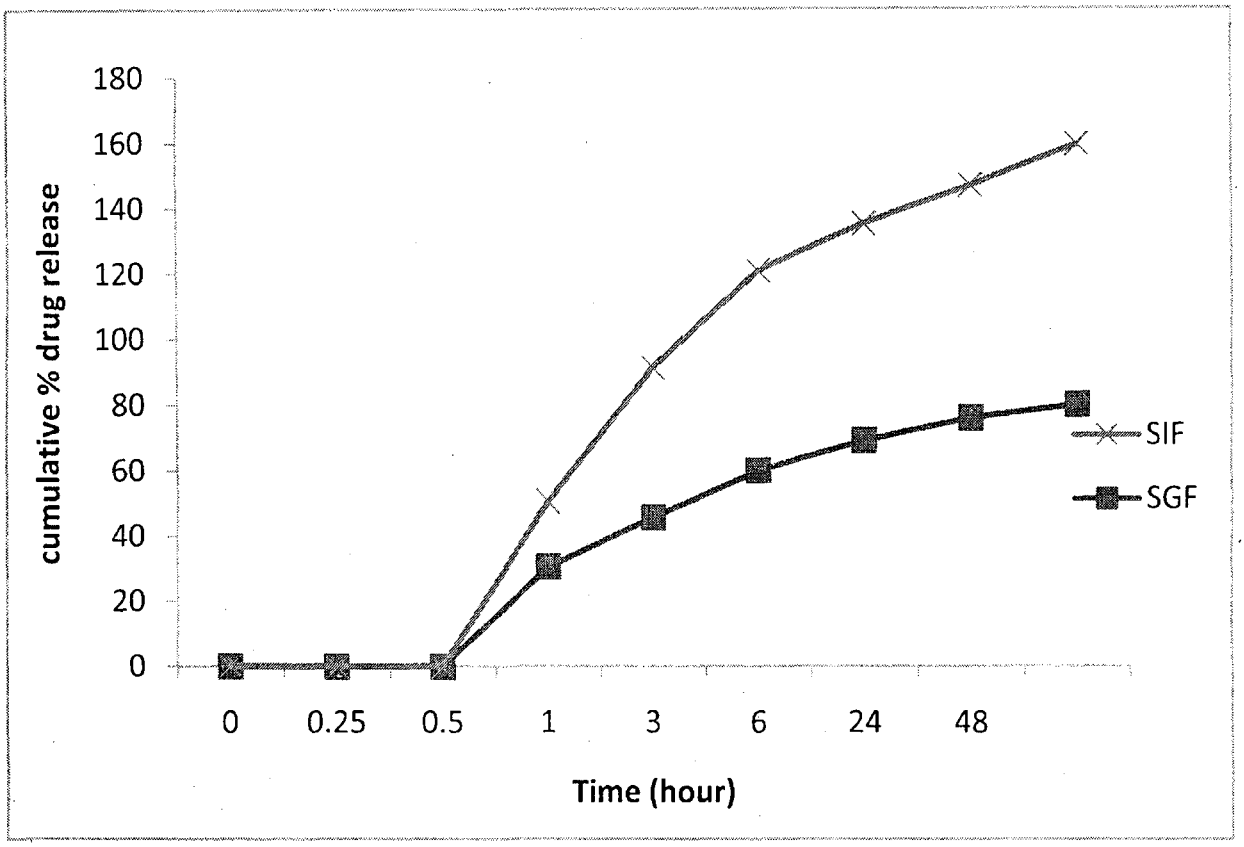


Fig. 4: *In vitro* release pattern of zidovudine encapsulated in PLGAnanoparticles in SGF and SIF.

problems encountered during the treatment of devastating infections.

ACKNOWLEDGEMENTS

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MONOGRAPH ON THE FISHES OF HARYANA STATE (INDIA)

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ABSTRACT

The extensive ichthyological survey of Haryana State (India) undertaken during July 2005 to June 2006 has revealed the occurrence of 65 fish species belonging to nine orders namely Synbranchiformes, Clupeiformes, Osteoglossiformes, Cypriniformes, Siluriformes, Beloniformes, Cyprinodontiformes, Mastacembeliformes and Perciformes in various water bodies. Out of sixty five fish species nine species viz., *Catla catla* (Ham.), *Cirrhinus mrigala* (Ham.), *Labeo calbasu* (Ham.), *Labeo rohita* (Ham.), *Tor putitora* (Ham.), *Channa marulius* (Ham.), *Sperata seenghala* (Sykes), *Clarias batrachus* (Linn), and *Wallago attu* (Schn.) constitute the major capture fishery. More than fifteen species are included in the minor capture fishery of the state. Interestingly,eight exotic species namely *Hypophthalmichthys* molitrix (Val.) *Hypophthalmichthys nobilis* (Richardson), *Ctenopharyngodon idellus* (Val.), *Cyprinus carpio communis* Linn., *Cyprinus carpio specularis* Lacepede, *Oreochromis mossambicus* (Peters), *Clarius gariepinus* (Burchell) and *Gambusia affinis* (Baird and Girrad) which have been introduced in the past for various specific purposes mainly to enhance the culture fish production, control of macrophytes, blooms of phytoplankton and insects have made their entry to natural waters, hence, at this moment these fishes are considered to be part of natural fish fauna of Haryana State. The natural water bodies in the vicinity of northern part of the state bordering Himachal Pradesh have good number of typical hillstream fishes. Besides, more than twenty fish species particularly the minnows are considered excellent aquarium fishes because of their attractive colouration, varied shapes of barbels and having transparent bodies. Overall the fish fauna of Haryana State comprises of fishes preferring well oxygenated waters, oxygen deficient waters, large size fishes and small size fishes too due to the existence of varied ecological conditions. Further, the species diversity in this state is low when compared with neighbouring states namely, Himachal Pradesh, Punjab, Rajasthan, Uttar Pradesh and Uttaranchal.

Keywords: *Fishes, Haryana State, Field Key*

INTRODUCTION

Fish diversity study has a global dimensions and it is to be treated as an essential pre-requisite for any aquatic habitat. In this context, the diversity (especially fishes) has to be indexed to facilitate its preservation and conservation as it has direct relevance to the water quality and livelihood for the natives.

Inland fisheries in Haryana state does not have any concrete evidence of their fish faunal status since 1982 with the last available research work of Kaul *et al.* (1982). Before that, some earlier reports such as of Tandon and Sharma (1965), Tandon (1969), Rishi and Dattagupta (1979), Vats (1979), Agarwal (1982), Kaul *et al.* (1982), Rishi and Shah (1982) and very recent by Moza and Mishra (2003) are available, but all these reports could not describes the exact status of the fish diversity of this State. Documented review by Johal and Rawal (2004) is primarily based on the findings of the reports available earlier and gives bleak picture on the fish diversity of Haryana state.

Although there are good records (Tandon and Thind, 1963; Tandon, 1967; Tandon and Rishi, 1967; Tandon, 1969; Tandon and Johal, 1972; Menon, 1974; Tandon and Gupta, 1975; Tilak and Husain, 1977; Johal *et al.*, 1993; Johal, 1998; Johal and Chahal, 1998; Johal *et al.*, 2002; Nautiyal, 2005; Negi *et al.*, 2007) on the fishes available in the different states adjoining to Haryana that might also indicate a good faunal diversity of this State as most of the rivers (either originating or passing through) has direct or indirect connection with the water bodies of Haryana.

As far as the fish faunae of the adjoining states of Haryana are concerned, this state is surrounded by the land mass which has very rich fish species diversity as well as perennial rivers and streams. The combined assessment made by Johal and Jha (2010) on the neighbouring states and their fish species throws a significant light on the richness in fishes of these states which constitute 18.8% of the freshwater fish fauna of Indian sub-continent (Jayaram, 2010) comprising 196 fish species belonging to 10 orders,

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28 families and 82 genera. Out of these, the maximum number of fish species occur in the waters of Punjab (117) followed by Rajasthan (107), Himachal Pradesh (91) and Uttarakhand (76). The figure of fish species mentioned above for the State of Haryana in this documentation is not the actual number of fishes prevailing at the current situation in Haryana because of absence of latest authenticated reports of any survey done either by any educational institution or by any other credible government body of this state since 1982.

Keeping in view the above cited lacunae, Department of Fisheries, Haryana and Fish and Fisheries Laboratory, Department of Zoology, Panjab University, Chandigarh initiated a collaborative project to evaluate the present status of fish diversity of Haryana State, hitherto unknown (Fig.1). This project has been completed by executing a thorough and extensive survey of various districts of Haryana including its two major rivers , *viz.*, Yamuna and Ghaggar along with their tributaries and associated canals for a period of one-year (July 2005 - June 2006).

After the completion of this project and conducting an extensive survey of the various water bodies located in the vicinity of Haryana State, the present monograph has been prepared so that the future fishery workers in this state must have first hand information on the fish diversity of this state. Further, this monograph will also help the future fishery workers to identify the fishes correctly up to species level. As many as 65 fish species have been collected, hence, being described in this monograph.

The classification given in this monograph is after Greenwood *et al.* (1966, 1967) and adopted by Talwar and Jhingran (1991) and Jayaram (2010) with slight modifications, wherever necessary. For the actual identification of the fish species under report, the works of Hamilton (1822), Day (1878), Johal and Tandon (1979, 1980), Talwar and Jhingran (1991) and Jayaram (2010) have been consulted. To have past history of the species included in this monograph, the synonyms of each species are given. The dichotomous keys included in this monograph related to the reported fish species are based on the morphological and meristic characters observed by the authors. For the easy identification, the actual coloured photographs of each fish species are given, which are grouped in eight plates. In the fish formula, only fin ray counts are given, scale counts are discussed in the description of the fish. Duplication of the description of characters has been avoided. For the definition of the various characters used for the purpose of identification of fish species, for the construction of keys and for the detailed description of the species under report are after Jayaram (2110). To avoid any confusion, none of the definition described by Jayaram (2010) has been modified. The generic characters have been adopted from Johal and Tandon (1979,1980), Talwar and Jhingran (1991) and Jayaram (2010) without any modifications. The relevant synonyms of the fishes under report are adopted from Menon (1974).

In this monograph, the description of only those fish species is given which are collected by the authors by putting every type of effort. There is a possibility that some fish species might have escaped our notice. A complete analysis of the fishes which disappeared, appeared, reported for the first time, conservation status of each reported fish species and fish diversity of Haryana State *vis-a-vis* neighbouring state are discussed in the earlier publications (Johal *et al.*, 2010; Johal and Jha, 2010).

It is needless to mention that the State Fishery department, Haryana have given their full support and co-operation at every stage (financial as well as administrative support) and extend all the necessary facilities for the collection of fishes and to formulate this data. Without their help and active support, this work would have been impossible to complete in this manner. However, there may have been some lacunae in this monograph despite our best efforts, hence, the authors would gracefully welcome any such suggestions and criticism.

The fishes described herein belong to nine orders namely Synbranchiformes, Clupeiformes, Osteoglossiformes, Cypriniformes, Siluriformes, Beloniformes, Cyprinodontiformes, Mastacembeliformes and Perciformes (Superclass Gnathostomata; Grade Teleostomi; Class Actinopterygii; Subclass Neopterygii; Division Teleostei.

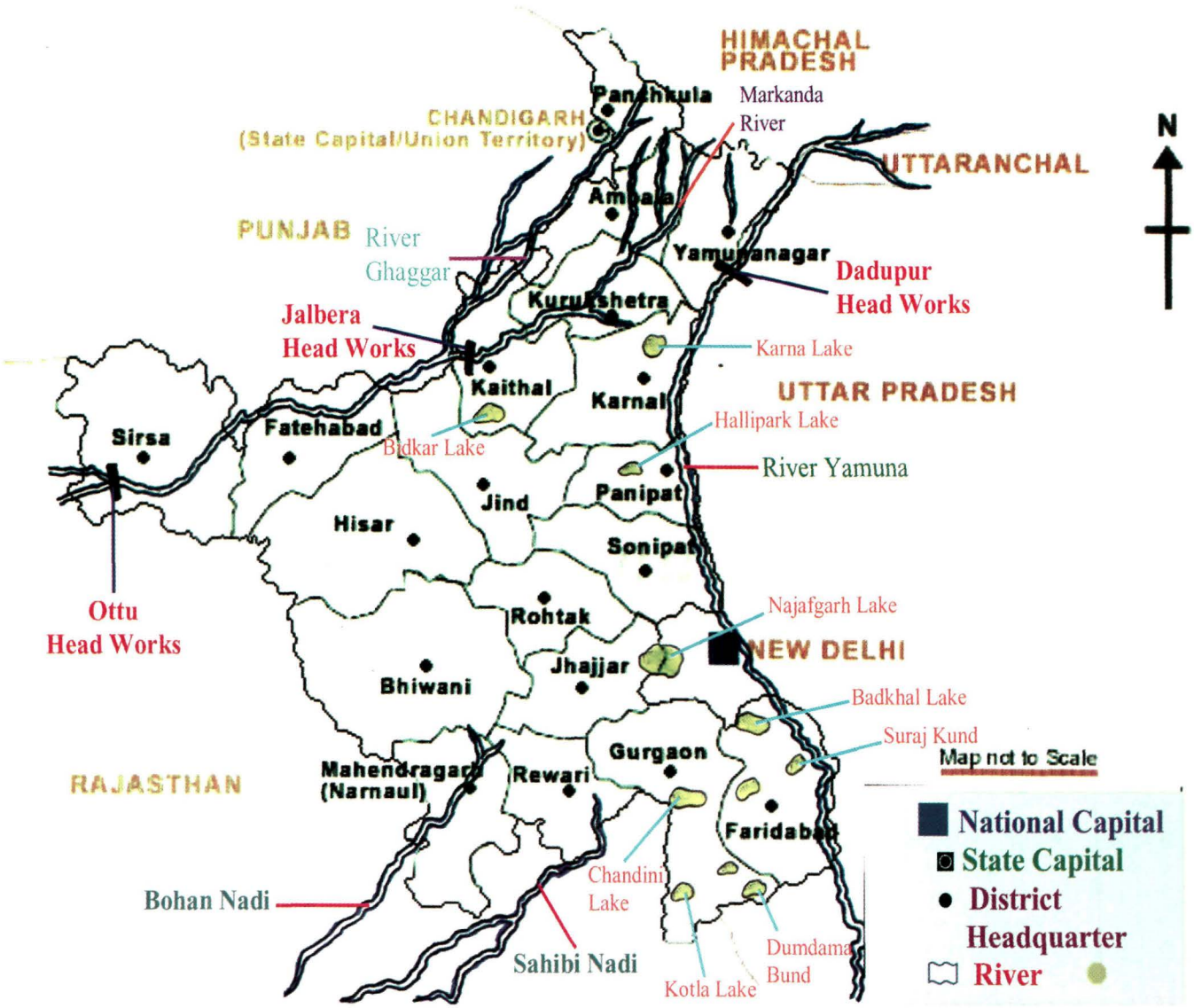


Fig. 1: Map of Haryana State Showing Distribution of Rivers and Lakes

OBSERVATION

The detailed observations of these fishes emphasizing every minute characteristics have been formulated below along with some added features which were not been highlighted by the previous workers.

Superclass: GNATHOSTOMATA

(having Jaws)

KEY TO CLASSES

Class: (a) Chondrichthyes (*Cartilaginous fishes*): Gill-openings are 5 on each side of head.(not included in the monograph).

(b) Osteichthyes (*Bony fishes*): Gill-openings one on each side of the head covered with operculum.

Subclass: ACTINOPTERYGII

(Ray-finned Fishes)

Fins supported by branched, segmented, horny soft-rays (lepidotrichia) and unbranched spinous-ray or hard-rays; skeleton well ossified with numerous investing bones in the skull, operculum and pectoral girdle; caudal fin or tail is generally homocercal or have symmetrical lobes (except in some primitive

forms which possesses heterocercal or semi-heterocercal caudal fin); scales (if present) are overlapping and are cycloid or ctenoid in nature or both; 4 pair of gill arches and gills covered by bony operculum; internal nostrils are absent; nasal openings on each side usually double and more or less dorsal; spiracles absent and a gill-cover called **'Operculum'** covers the gill-slits; air-bladder present; claspers are absent and fertilization of eggs external except *Gambusia affinis* (Baird and Girard).

Division: TELEOSTEI

Include the advanced bony fishes such as carps, catfishes, freshwater eels and perches etc.

KEY TO ORDERS

1. Body cylindrical, elongated (eel-shaped)..... (2)

   Body cylindrical or rounded (not eel-shaped).....(5)

2. Ventral fins absent; gill openings confluent with body; body with one or two gill opening; pectoral fins may or may not be present. .....**(Order: SYNBRANCHIFORMES)**

   Ventral fins present. .....(3)

3. Ventral fins abdominal. .....(4)

   Ventral fins thoracic. .....(7)

4. Ventral fins reduced; abdominal scutes were present. ..... (5)

   Ventral fins well developed; abdominal scutes absent. ..... (6)

5. Anal fin moderate, without spines and not confluent with the caudal fin; jaws without teeth; head without muciferous channels; lateral line absent; no weberian apparatus (Isospondyli).....**(Order: CLUPEIFORMES)**

   Anal fin confluent with caudal fin; jaws toothed; head with muciferous channels. ....**(Order: OSTEOGLOSSIFORMES)**

6. Body covered with cycloid scales; devoid of bony plates; barbels if present, are minute or small; adipose fin mostly absent; no scales on head; no teeth on jaws; pectoral fins devoid of osseous-spine; lateral line distinctly visible; a peculiar weberian apparatus connecting ear with air bladder is present (Osteriophysi) .....**(Order:CYPRINIFORMES)**

   Body naked or either covered with horny plates; barbels 4 pairs (maxillary pair especially long); adipose fin mostly present; pectoral fins with its outermost ray modified into osseous-spine or a thick hard-ray. .....**(Order: SILURIFORMES)**

7. Jaws produced into long-beak with sharp teeth at its edges; body elongated and cylindrical; body elongated and covered with deciduous cycloid scales; pectoral fins wing-like, no spines in fins. .....**(Order: BELONIFORMES)**
   Jaws not produced into beak. .....(8)

8. Fins without spines; lateral line chiefly on head not extended to the body; larvivorous in habit. ..... **(Order: CYPRINODONTIFORMES)**

   Head especially covered with large plate-like scales; dorsal fin separated into two parts (D1 with spinous-ray and D2 with soft-rays) with a small gap or notch between them; ventral fin united to form a sucking disc mostly; no webarian apparatus. ..... **(Order: PERCIFORMES)**

KEY TO GENERA OF ORDER CLUPEIFORMES

Subdivision	:	**Clupeomorpha**
Order	:	**Clupeiformes**
Family	:	**Clupeidae**
Subfamily	:	**Alosinae**

Genus: *Gudusia* Fowler

1911, *Gudusia*, Fowler. *Proc. Acad. Nat. Sci. Philad.*, **63**: 207.

Body well compressed, oblong with serrated abdomen (keeled); head short, compressed with conical rounded snout; mouth oblique, cleft not extending to eye-orbit; upper jaw with a distinct notch; eyes large, laterally placed with free adipose eyelids; dorsal fin situated opposite to pelvic fin; anal fin with less than 30 rays; caudal fin deeply forked; scales small, cycloid and not in a definite pattern; lateral line indistinct with 80-90 scales in lateral line series.

***Gudusia chapra* (Hamilton-Buchanan) (Fig. 1)**

Syn. 1822, *Clupanodon chapra*, Hamilton-Buchanan. *Fish. Ganges*, pp. 248, 383.

1878, *Clupea chapra*, Day. *Fish. India*, p. 639.

1917, *Gudusia chapra*, Regan. *Ann. May. Nat. Hist.*, **8**: 307.

1959, *Gudusia chapra*, Misra. *Rec. Indian Mus.*, Vol. **57**: 119; Misra, 1976. *Fauna of Indian Pisces* (2nd ed.), **2**: 61.

1991, *Gudusia chapra*, Talwar and Jhingran. *Inland Fishes*, **1**: 96, fig. 33.

1999, *Gudusia chapra*, Jayaram. *The Freshwater Fishes of The Indian Region*, p. 41, fig. 26.

Fin formula: $D_{iv/11-12}$ $A_{ii/21}$ $P_{i/11-12}$ $V_{i/7}$

Common Name: Palla, Chappera, Pharanda.

External Characters: Body compressed and fairly deep, its depth being 2.8-3.2 times in standard length; mouth wide; teeth absent; hinder edge of maxilla extends to below middle of eye; abdominal profile sharp with about 28-29 scutes on ventral side (20 scutes before ventral fin and 8-9 behind or post-ventral); dorsal fin inserted more or less equidistant to the snout-tip and caudal fin base; length of pelvic fin is eqal to minimum body depth; distance between pectoral to pelvic to anal fin is almost same; 83-85 scales in lateral series; pre-dorsal scales count 22-24.

Colour: Silvery with dark dorsal surface, golden spot on the shoulder, 9-11 spots on the upper margin of body in fresh specimen (which reduces to single spot behind the operculum on preserved condition).

Location: Yamunanagar (Dadupur Headworks), Ambala, Karnal, Panchkula (Nada Sahib).

KEY TO GENERA OF ORDERS CYPRINIFORMES AND SILURIFORMES

1. Skin covered with cycloid scales; mouth protractile with toothless jaws; adipose fin absent; barbels often present; lateral line present and distinct; air- bladder free or enclosed in bony capsule.....**(Suborder: Cyrinoidei)**..... (2)

   Skin naked; mouth not protractile; jaws toothed; 1-4 pairs of barbels (maxillary generally long than other); 1st pectoral and last dorsal ray modified to form hard spines; air-bladder subdivided or reduced in many species. ..... **(Suborder: Siluroidei)**.....(24)

2. Pelvic and pectoral fins inserted horizontally with at least 2 undivided pectoral fin rays. .....(3)

   Pelvic and pectoral fin are inserted laterally; pectoral fins have only one undivided or may be all branched ray.....(4)

3. Barbels three or more pairs present; suborbital spine absent; air-bladder partly enclosed in bony capsule; body depressed..... **(Family: Balitoridae)**.....(20)

4. Eyes prominent; barbels one or two pairs or even absent; no suborbital spine; body laterally compresses.....**(Family: Cyprinidae)** .....(5)

   Eyes subcutaneous; barbels three or four pairs; suborbital spine before or under the eye generally present; body elongated to fusiform.....**Family:Cobitidae)**.....(21)

5. Abdomen rounded, compressed laterally; lateral line in the middle of body; upper lip separated from skin of snout. ..... **Subfamily: Cyprininae)** .....(7)

   Abdomen rounded or flat, not compressed; barbels one or two pairs present or absent; upper lip continuous with skin of snout; mouth conspicuously inferior, lower lip with or without a suctorial disc..... .....**Subfamily: Garrinae)** .....(13)

6. Abdomen entirely keeled form throat to vent; scales minute, not extended to inter-orbital space; operculum large deeper than longer; anal fin elongated; barbels absent; lateral line curved downward towards ventral side. ..... **(Subfamily: Leuciscinae)** .....(16)

   Abdomen rounded or laterally compressed; lateral line when complete, have an abrupt downward curve anteriorly, close to the ventral edge..... .....(Subf**amily: Danioninae)** .....(16)

   Abdominal edge cultrate (knife like or sharply keeled); Eyes moderate; to large, not visible from underside of head; no particular modifications of gill arches; anal fin with at least nine barbels..... **Subfamily: Cultrinae)** .....(19)

7. Dorsal fin commences in advance of ventral; anal fin with 5-8 rays. .....(8)

Dorsal fin commencing very distinctly posterior to ventral fin; anal fin with 10-35 rays. .....(15)

8. Mouth upturned; head very large..... .....**(Genus: *Catla*)**
   Mouth not upturned. .....(9)

9. Mouth inferior. .....(10)
   Mouth terminal. .....(14)

10. Adhesive disc absent on lower lip. .....(11)

    Adhesive disc present on lower lip. .....(13)

11. Lip(s) thick, continuous at the angles of mouth. ..... (12)
    Lip(s) thin, not continuous at the angles of the mouth; dorsal fin without a spine; barbels one or two pair.....Genus: Cirrhinus)

12. Mouth inferior or subterminal; one or both lips (especially lower one) fringed, possessing soft and moveable cartilaginous coverings but covered with thick labial folds; dorsal spine absent; barbels usually one pairs,maxillaryonly .....**(Genus: *Labeo*)**

    Mouth terminal; lower lip not continuous with upper lip and developed a fleshy lobe below mandibular symphysis; cheeks with tubercles; scales large with 22-30 lateral line scales; gill raker on lower limb more than 10; barbels well developed. .....**(Genus: *Tor*)**

13. Upper lip fringed; lower lip possesses a suctorial-disc (circular or elliptical); barbels two paired; scales of moderate size. .....**(Genus: *Garra*)**

    Lower lip simple without any modification, upper and lower lip not connected. ..... **(Genus: *Crossocheilus*)**

14. Dorsal fin long with 19-23 rays, barbels two pairs; lateral line complete with 30-34 scales. .....**(Genus: *Cyprinus*)**

    Dorsal fin of moderate length with 8-11 rays; barbels 4, 2 or none; lateral line complete or incomplete with 23-32 rays; scales with few or strongly radiating striae; no horny covering on inner side of lips, lips distinct. .....**(Genus: *Puntius*)**

15. Lateral line straight or nearly straight; dorsal fin inserted posterior to the base of pelvic fins, generally in the space between pelvic fins and anal fin; abdominal edges sharp; anal with 27-35 rays. .....**(Genus: *Osteobrama*)**

    Lateral line not straight; anal with 10-15 rays. .....(16)

16. Lateral line concave; anal fin with 10-12 rays; lower lip absent; lower jaw with crescentic edges; barbels absent. .....**(Genus: *Aspidoparia*)**

    Lateral line with irregular course; entire or only post-ventral edge of abdomen keeled or carinated; gill raker continuous forming crescentic horny membrane or remain separated, slender and long. ..... **(Genus: *Hypophthalmichthyes*)**

17. Symphysial knob present on the lower jaw. .....(18)
    Symphysial knob absent. .....(19)

18. Cleft of mouth often extending beyond anterior margin of eye; mouth anterior; anal fin rays 11-15 in number; barbels 4, 2 or none; regular or irregular spots or bars present on the body on either side. .....**(Genus: *Barilius*)**

    Cleft of mouth not extending beyond anterior margin of eye; upper lip absent; lateral line incomplete; anal fin rays 8 in number; barbels absent. .....**(Genus: *Amblypharyngodon*)**

19. Anal fin rays 18-24; mouth directed somewhat upwards; Symphysial knob on the lower jaw absent; pre-dorsal scales do not extend to inter-orbital space; lateral line curved downwards.....**(Genus: *Chela*)**

    Pectoral fins long with an axillary-ray may not reach the pelvic fins; lateral line curved gently downwards above pectoral fin; pelvic fin origin nearer to anal fin than to pectoral fin base. .....**(Genus: *Salmostoma*)**

20. Dorsal fin without a spine; head devoid of sensory fold; pharyngeal teeth in two rows; lateral line complete. ..... **(Genus: *Ctenopharyngodon*)**

    Dorsal fin with eight branched rays and a spine, strongly serrated; head with numerous sensory folds; lateral trunk scales without radii; lips covered with dense tiny papillae. ....**(Genus: *Chugunius*)**

21. Bifid suborbital spine present; barbels 6, 8 or more (if 8 then four rostral, two maxillary and two mandibular). ..... (22)

    Sub-orbital spine absent; barbels 6 (four rostral, two maxillary); no mandibular barbels; body partly

covered with minute scales; belly horizontal; a dark spot in the middle of caudal fin base. .....**(Genus: *Nemacheilus*)**

22. Two pairs of rostral barbels present along with maxillary and mandibular pair; caudal fin deeply emarginate or forked. .....**(Subfamily: Botinae)** .....(23)

    One pair of rostral barbels present (rarely absent); caudal fin usually rounded or slightly emarginated. .....**(Subfamily: Cobitidae)** .....(23)

23. Scales on head absent; dorsal fin in advance of pelvic fin (always) and in the middle of the body; head with erectile spine present near eye; usually with a pair of fused maxillo-mandibular barbels at mouth. .....**(Genus: *Botia*)**

    Scales present on the head; dorsal fin inserted midway (in advance or slightly behind) the pelvic fin base; lateral line absent. ....**(Genus: *Lepidocephalus*)**

24. Dorsal fin with spine; adipose dorsal fin also present. ..... (25)

    Dorsal fin spineless; adipose dorsal fin absent. ..... (35)

25. Anal fin short with 8-16 fin rays; nostrils are close together separated by a barbel or valve. .....(26)

    Anal fin short; nostrils wide apart, posterior with a nasal barbel; pectoral spine strong. .....**(Family: Bagridae)** .....(28)

26. Lateral line always present; distinct nasal barbels present; barbels 4 pairs; mostly small forms occurring in mountain rapids; gill membrane united with isthmus except in *Bagarius*(Ham.)... .....**(Family: Sisoridae)** .....(29)

    Lateral line entirely absent; gill membrane free from isthmus; no teeth on roof of mouth; dorsal and pectoral spines weak; body profile more or less horizontal suitable for inhabiting swift streams. ..... **(Family:Amblyceptidae)** .....**(Genus: *Amblyceps*)**

27. Dorsal fin very long with 62-76 rays; anal fin rays 50-58 (both reaching upto the base of caudal fin); caudal fin rounded; nasal barbels present; accessory respiratory (labirynthic) organ present on gills in branchial chamber. ..... **Family: Clariidae)** .....(29)

    Dorsal fin short, without any spine; anal fin may or may not free from caudal fin; caudal fin forked; nasal barbels absent; no accessory respiratory organ. ....**(Family: Siluridae)** .....(30)

28. Eyes superior (not visible from below ventral surface); an inter-neural shield between basal bone of dorsal fin and occipital process present; maxillary barbels long reaching up to anal fin; a dark black spot at the base of dorsal adipose fin. ..... **(Genus: *Sperata*)**

    Eyes prominent with free circular margin; dorsal and pectoral spines not very strong; head generally with median longitudinal groove; inter-neural shield absent; barbels 4 pairs; maxillary usually extending beyond head; no spot at the base of adipose fin. .....**(Genus: *Mystus*)**

29. Eyes small, subcutaneous without free circular margin; head more depressed adhesive disc present on the ventral surface, extending from lower lip to opposite middle of pectoral fins base in the form of longitudinal folds; barbels short and thick; adipose dorsal fin distinctively separated from rayed dorsal fin; caudal fin deeply forked. .....**(Genus: *Glyptothorax*)**

    Eyes not visible from ventral side; head dorso-ventrally flattened; abdomen laterally compressed; pectoral fin well-developed with strong spinous ray; caudal fin rounded; accessory dendritic-apparatus in branchial cavity for breathing; lateral line distinct; no scales on the body; all barbels long. .....**(Genus: *Clarius*)**

30. Dorsal fin one, very short with 4-5 rays; barbels 4; gape of mouth very wide; cleft extends beyond eyes posteriorly; anal fin rays 84-96. .....**(Genus: *Wallago*)**

    Dorsal fin short, with 6-7 rays; anal rays 60-74; barbels 8, more or less equal; head more flat and depressed; accessory respiratory organ in the form of long air-sac (serving lungs) present in body cavity near branchial chamber; pectoral fins with a strong spine; caudal fin slightly rounded or truncated; lateral line complete. .....

    .....**(Family: Heteropneustidae)**

    .....**(Genus: *Heteropneustes*)**

KEY TO GENERA OF ORDER PERCIFORMES AND SYNBRANCHIFORMES

1. A suprabranchial organ present; ventral fin moderately apart. .....(2)

   Suprabranchial organ absent; ventral fin close together. .....(3)

2. Dorsal and anal fins with spines; each ventral fin reduced to a single filamentous ray; pelvic fins thoracic usually each with one spine and 5-soft rays...

   .....**(Suborder:Anabantoidei)**.....(6)

   Dorsal and anal fins long and without spines; ventral or pelvic fin sub-abdominal with 6-soft rays. .....**(Suborder: Channoidei)** .....**(Family: Channidae)** .....**(Genus: *Channa*)**

3. Pelvic fin placed below pectoral fins each with one spine and 4-5 soft rays, often united; head with mucous canal and open pores; ventral fin close together to form sucker disc..... .....**(Suborder: Gobidei)** .....(7)

   Pelvic fin thoracic or abdominal, each with one spine and 5-rays; anal fin with two or three spines. .....(4)

4. A pair of nostrils on each side is present. .....**(Suborder: Percoidei)** .....(8)

   A single nostril on each side is present. ....**(Suborder: Labroidei)** .....(9)

5. Pre-orbital spine may be absent. .....(10)

   Pre-orbital spine absent. ..... (6)

6. Pre-vomerine teeth present; lateral line break-up at 15th scale to form 2 distinct rows; upper jaw only weakly protrusible...**(Family: Anabantidae)** .....**(Genus: *Anabas*)**

   Pre-vomerine teeth absent; lateral line usually vestigial or absent, but if present either discontinuous or continuous with break-up at two places. .....**(Family: Belontidae)** .....**(Genus: *Colisa*)**

7. Body oblong or elongate but not eel-like; scales above behind eyes; pelvic fin united, usually forming an adhesive or sucking-disc; caudal fin pointed or lanceolate; scales ctenoid or cycloid. .....**(Subfamily: Gobiinae)** ..... **(Genus: *Glossogobius*)**

   Body oblong or fairly deep; less than half a total length; two dorsal fin with their bases separated but if close together are not joined by a membrane; 1st dorsal fin with 7-9 spines; lateral line not distinctively visible, but complete; caudal fin forked ..... **(Family: Chandidae)** .....(8)

8. Canine teeth on lower jaw; scales minute, 100-107 in longitudinal series; mouth fairly large; with very prominent lower jaw. .... **(Genus: *Chanda*)**

   Canine teeth absent on lower jaw; scales 70-90 in longitudinal series; mouth moderate; lower jaw more or less equal to upper jaw. ....**(Genus: *Parambassis*)**

9. Single nostril present on each side of the snout; lateral line interrupted or abruptly ceasing; dorsal fin single with 17-22 spinous and 11-15 soft rays. ..... **(Family: Cichlidae)** ..... **(Genus: *Oreochromis*)**

10. Body elongated (eel-like) with no ventral or pelvic fins; dorsal and anal fin continuous with the caudal fin; pectoral arch attached to vertebral column by a ligament; no duct to airbladder(physoclistic)..... .....**(Suborder: Mastacembeloidei)**

    Dorsal fin with 32-39 depressible spines; pre-opercle generally spiny at its angle; anal fin with 3 spines; rim of anterior tubular nostrils with two finger-like projections and two broad based flaps; rostrum small..... **(Family: Mastacembelidae)** ..... **(Genus: *Mastacembelus*)**

KEY TO GENERA OF ORDER BELONIFORMES

Nasal opening single; lateral line low (towards ventral side) on the body; both jaws elongated to form beak; paired fins are small; dorsal fin inserted nearly opposite to anal fin origin.. .....**(Family: Belonidae)** .....**(Genus: *Xenentodon*)**

KEY TO GENERA OF ORDER CYPRINODONTIFORMES

Dorsal fin inserted behind anal fin origin; pelvic fins not close, inserted apart; caudal peduncle length longer than head length; males with anterior anal fin elongated and modified to form **'gonopodium'** which bears the young-ones; distal and sub-distal zones of melanophores on dorsal and caudal fin. ....**(Family: Poicilidae)**

.....**(Genus: *Gambusia*)**

DESCRIPTION OF THE GENERA OF ORDER CYPRINIFORMES

Subdivision : Euteleostei

Superorder : Ostariophysi

Order : Cypriniformes

Family : Cobitidae

Subfamily : Botinae

Genus: *Botia* Grey

1831, *Botia*, Grey. *Zool. Misc.*, p. 8.

Body oblong, short or robust and laterally compressed; head long and pointed; abdomen slightly rounded; snout conical and flattened ventrally; eyes with free circular margins; mouth small, ventral with thick lips; barbels six to eight (4-rostral barbels united at their bases on snout); nostrils close together with anterior nostril tubular-one; bifid, erectile sub-orbital spine below or infront of eyes; dorsal fin inserted equidistant from the snout and base of caudal fin; scales absent on head and on the body very minute and indistinct; caudal fin deeply forked; lateral line distinct.

***Botia birdi* Chaudhuri (Fig. 2)**

Syns. 1909, *Botia birdi*, Chaudhuri. *Rec. Indian Mus.*, **3**(4): 339, 342.

1922, *Botia birdi*, Hora. *Rec. Indian Mus.*, **24**(3): 319.

1972, *Botia birdi*, Tandon and Johal. *Res. Bull. Panjab Univ.*, **23**: 46.

1991, *Botia birdi*, Talwar and Jhingran. *Inland Fishes*, **1**: 536.

1999, *Botia birdi*, Jayaram. *The Freshwater Fishes of The Indian Region*, p. 210.

Fin formula : D. $_{i/10}$ A. $_{i/6}$ P. $_{14}$ V. $_{i/7}$

Common Name: Chipar, Kandar, Birdi loach.

External Characters: Body oblong and laterally compressed, its depth being 4.1-4.5 times in standard length; head moderate, inferior; eyes small, its diameter is more than 7 times in head length, 4 times in the length of snout and 2-2.5 times in inter-orbital width; mouth small, ventral; barbels four pairs (2 pair rostral, 1 pair maxillary and 1 pair mandibular), maxillary barbels are twice in length as that of mandibular and reaches the middle of the eye, length of rostral barbel intermediate to that of mandibular and maxillary, the outer and upper rostral pair being longer than the inner and inferior rostral pair; lips thick, suctorial; dorsal fin inserted in middle of the body; pelvic fin equidistant from pectoral and anal fin; length of pelvic equals to minimum body depth, caudal fin forked; scales minute, deciduous and present all over the body except head; lateral line distinctly visible.

Colour: Snout reddish at the time of catch; rostral barbels dark-brown; general body colour yellowish with 3 well marked Y-shaped bands with their two outer limbs meeting on the dorsal side, while the median band meets just below the dorsal fin; dorsal and anal fin with 3 black strips or broad bands; pectorals, pelvics and caudal fin with 4, 1 and 4-5 vertical black stripes respectively.

Location: Panchkula (Nada Sahib).

Genus: *Lepidocephalus* Bleeker

1858, *Lepidocephalus*, Bleeker. *Nat. Tijdschr. Ned. Inde.*, **16**: 303.

Body elongated with low-depth and laterally compressed caudal peduncle; head short, conical with blunt snout; mouth sub-terminal or inferior; lips thick and fleshy, lower lip interrupted; eyes small, superior covered with transparent skin; bifid, erectile sub-orbital spine present; mouth inferior; barbels 6 (one pair each of rostral, mandibular and maxillary); mental lobe well-developed in the form of short thread like elongation (looks like another barbel); dorsal fin short, commencing opposite or slightly behind the ventral fins origin having 8-9 rays; caudal fin truncated or slightly emarginate; scales very small; lateral line absent.

***Lepidocephalus guntea* (Hamilton-Buchanan) (Fig. 3)**

Syns. 1822, *Cobitis guntea*, Hamilton-Buchanan. *Fish.* Ganges, pp. 353, 394.

1878, *Lepidocephalus guntea*, Day. *Fishes of India*, p. 609.

1981, *Lepidocephalus (Lepidocephalichthyes) guntea*, Tilak and Husain. *Occ. Paper Rec. Zool. Surv. India*, **32**: 7, figs. 1-4.

1991, *Lepidocephalus guntea*, Talwar and Jhingran. *Inland Fishes*, **1**: 525, fig. 171.

1999, *Gudusia chapra*, Jayaram. *The*

Freshwater Fishes of The Indian Region, p. 217, fig. 107A.

Fin formula: D. $_{ii/6}$ A. $_{ii/5}$ P. $_{i/6-7}$ V. $_{i/6}$

Common Name: Jiwal, Guntea loach.

External Characters: Body elongated, streamlined with low-depth (its depth being 5.4 times in standard length) and posteriorly compressed, its depth being 6-7 times in standard length; mouth inferior, narrow and arched; barbels six, mandibular barbels rudimentary; mental lobe well-developed giving a false impression of a pair of barbel; dorsal fin inserted slightly behind the origin of pelvics (on 2nd half of the body); anal fin short; caudal fin truncated with rounded corners; scales small, covering the lateral and ventral side of head along with the body; lateral line absent.

Colour: Body colour yellowish, generally on dorsal side; black ocellus in the upper half of caudal fin; several dark black blotches present along lateral line which grows with age and tends to fuse in older specimen forming a continuous dark lateral band extending from snout upto the caudal fin base; black streak extends from anterior end of eye to end of snout; dorsal and caudal fin with row of dark spots or stripes.

Location: Panchkula (Nada Sahib).

Superorder : Ostariophysi
Order : Cypriniformes
Family : Balitoridae
Subfamily : Nemacheilinae

Genus: *Nemacheilus* Bleeker

1863, *Nemacheilus*, Bleeker. *Versl. Akad. Amsterdam*, **15**: 34.

Body elongated, almost cylindrical, slightly depressed with rounded abdomen; dorsal profile slightly arched; mouth small and inferior; eyes small, not visible from ventral side of head; lips thick and fleshy; eyes dorso-lateral in position; sub-orbital spines absent; barbels 2-4 pairs; dorsal fin short and inserted opposite to ventral fins; caudal fin emarginate, truncate or lunate; vent not close to anal fin; scale very small (rarely absent); lateral line complete.

Keys to Species

Because of lack of usual spines and other factors, this genus consists of group of species which shows remarkably similar general morphology. Certain closely observed characters which can provide useful tool in the identification of species are:

(i) Dorsal fin with 7-8 branched rays. ..... (ii) Dorsal fin with 9-11 branched rays; body slender with depth about 4.5-5.5 times of standard body length; body irregularly blotched; scales distinctly visible. ..... ***Nemacheilus botia***

(ii) Body without stripes or bands but with rounded or oval spots; a ray of pectoral fin greatly elongated; scales small; lateral line complete. .....***Nemacheilus corica***

Body with 9-12 broad vertical bands; scales absent; lateral line incomplete; no elongated pectoral fin ray. .....***Nemacheilus punjabensis***

(a) *Nemacheilus botia* (Hamilton-Buchanan) (Fig. 4)

Syns. 1822, *Cobitis botia*, Hamilton-Buchanan. *Fish. Ganges*, pp. 350, 394.

1878, *Nemacheilus botia*, Day. *Fish. India*, p. 614, pl. 156, fig. 5.

1910, *Nemacheilus mackenziei*, Chaudhuri. *Rec. Indian Mus.*, **5**(3): 183.

1987, *Nemacheilus botia*, Menon. *Fauna of India*, Pisces, **4**: 141, pl. 5, fig. 5.

1991, *Nemacheilus botia*, Talwar and Jhingran. *Inland Fishes*, **1**: 96, fig. 33.

1999, *Acanthicobitis botia*, Jayaram. *The Freshwater Fishes of The Indian Region*, p. 173, fig. 92.

Fin formula: D. $_{ii-iii/9-11}$ A. $_{iii/5}$ P. $_{iii/11}$ V. $_{i/7}$

Common Name: Sundli, Sundali.

External Characters: Body slender but having more depth (4.5-4.9 times in standard length) as compared to its other species; dorsal profile more arched than ventral; inter-orbital space slightly convex; nostrils close together; eyes moderate, visible from ventral from ventral side of head; mouth inferior, semicircular; lips thick, fleshy and tuberculated; lower lip interrupted in middle with a broad papillate disc on each side; barbels 6 (two pair rostrals, one pair maxillary), well-developed; outer rostral pair is equal in length to maxillary barbels; dorsal fin more towards the mouth than to caudal fin base; caudal fin slightly emarginate; very minute imbricate scales; lateral line

complete but inconspicous, sometimes diminishes or ended beyond anal fin; scales between lateral line and pelvic fin are either absent or reduced.

Colour: Body yellowish-orange in colour with 12-15 black twisted stripes of cross-bands; interrupted in young specimens; a narrow black dark band on snout from tip upto anterior margin of eyes; dorsal fin with 5 narrow bands; caudal fin with 6-7 V-shaped dark bands directed away from body; black ocellus on the upper portion of the base of caudal fin.

Location: Panchkula (Nada Sahib).

(b) *Nemacheilus corica* (Hamilton-Buchanan) (Fig. 5)

Syns. 1822, *Cobitis corica*, Hamilton-Buchanan. *Fish. Ganges*, pp. 359, 395.

1878, *Nemacheilus corica*, Day. *Fish. India*, p. 616, pl. 156, fig. 1.

1987, *Nemacheilus corica*, Menon. *Fauna India*, Pisces, **4**: 89, pl. 12.

1991, *Nemacheilus corica*, Talwar and Jhingran. *Inland Fishes*, **1**: 476.

1999, *Nemacheilus corica*, Jayaram. *The Freshwater Fishes of The Indian Region*, p. 175.

Fin formula: D. $_{ii/8}$ A. $_{ii/5}$ P. $_{i/10}$ V. $_{i/7}$

External Characters: Body elongated with uniform low-depth being 6-6.5 times of standard length; eyes small, not visible underneath the head; anterior nostril tubular; mouth inferior; lips fleshy, lower lip interrupted in middle; barbels three paired, moderately developed; dorsal fin inserted midway between snout-tip and caudal fin base; length and depth of dorsal fin almost same; pectoral fins usually longer than head and have 3rd fin-ray exceptionally longer than others; caudal fin deeply emarginate or forked; scales small, imbricate and more towards posterior-half; lateral line complete.

Colour: Body yellowish in colour with row of 10-11 oval to rounded spots long lateral long on both side of the body, no stripes.

Location: Karnal, Panchkula.

(c) *Nemacheilus punjabensis* Hora (Fig. 6)

Syns. 1923, *Nemacheilus punjabensis*, Hora. *Rec. Indian Mus.*, **25**(4): 384, figs. 2 and 3.

1972, *Nemacheilus alepidotus nalbanti*, Banarescu and Mirza. *Biologia*, **18**(2): 121, figs. 1 and 2.

1987, *Nemacheilus punjabensis*, Menon. *Fauna of India*, Pisces, **4**: 47, pl. 1, fig. 2.

1991, *Nemacheilus punjabensis*, Talwar and Jhingran. *Inland Fishes*, **1**: 497.

Fin formula: D. $_{iii/7-8}$ A. $_{ii/5}$ P. $_{i/9-10}$ V. $_{i/7}$

External Characters: Body elongated, its depth being 4.7-5.7 times in standard length; eyes small, dorso-laterally placed, not visible from underside of head; anterior nostril slightly tubular, being close to posterior nostril, mouth semicircular; lips thick, slightly furrowed and fleshy; 3 pairs of well-developed barbels; dorsal fin equidistant from snout-tip and caudal fin base; length of dorsal fin twice as that of anal fin; caudal fin slightly emarginate; scales absent; lateral line incomplete (not visible beyond anal fin).

Colour: Body colour grey with 10-12 dark vertical bands; a black stripe at caudal fin base, caudal fin lobes have two to three rows of spots; dorsal fin also spotted and has a black-blotch at the base of its anterior fin rays.

Location: Panchkula (Nada Sahib).

Superorder : Ostariophysi
Order : Cypriniformes
Family : Cyprinidae
Subfamily : Leuciscinae

Genus: *Hypophthalmicthys* Bleeker

1860, *Hypophthlamicthys*, Bleeker. *Nat. Tijdschr. Ned. Indie.*, **20**: 283.

Body elongated, deep and laterally compressed with keeled abdomen; head broad; eyes situated more or less below the axis of the body or set low on head; snout bluntly rounded; mouth large wide cleft and terminal with thin lips; supra-orbital long with thick crest; no barbels; dorsal fin comparatively smaller to anal fin with 10 rays (7 branched) and inserted behind the origin of pelvic or ventral fin; caudal fin forked scales minute and cycloid; lateral line more towards ventral side of body and complete. An exotic species, being introduced in India from China in 1959.

Keys to Species

(a) Entire abdominal edges keeled; gill-raker continuous forming crescentic horny membrane. ..... ***Hypophthalmichthys molitrix***

(b) Post-ventrals abdominal edge only keeled; gill-raker not continuous, slender with many membranous septa. .....

.....***Hypophthalmichthys nobilis***

(a) *Hypophthalmichthys molitrix* (Valenciennes) (Fig. 7)

Syns. 1844, *Leuciscus molitrix*, Valenciennes. *Hist. Nat. Poiss.*, **17**: 360.

1981, *Hypophthalmichthys molitrix*, Howes. *Bull. Br. Mus. nat. Hist.* (Zool.), **41**(1): 45.

1991, *Hypophthalmicthys molitrix*, Talwar and Jhingran. *Inland Fishes*, **1**: 330, fig. 117.

1999, *Hypophthalmicthys molitrix*, Jayaram. *The Freshwater Fishes of The Indian Region*, p. 62, fig. 40.

Fin formula: D. $_{iii/7}$ A. $_{ii/iii.12-13}$ P. $_{i/17}$ V. $_{i/7}$

Common Name: Silver carp.

External Characters: Body elongated, deep (its depth being 3.2-3.4 times in standard length) and compressed sharply beyond pelvic fins; dorsal profile more convex than ventral; abdomen keeled from breast to belly (throat to vent); head stout and broad, its length being 3.2-3.4 times in standard length; snout blunt; mouth terminal but oblique with lower jaw slightly longer than upper; inter-orbital space greatly convex; dorsal fin short as compared to body, inserted slightly behind the pelvic fin origin and more towards caudal fin base than to snout-tip; caudal fin forked; fine scales on the body; lateral line more towards ventral slide and with 95-102 scales; lateral transverse scales 28-32/13-15; pre-dorsal scales count 65-68.

Colour: Silvery-white body with transparent fins; dorsal surface greyish silvery in appearance in fresh specimens.

Location: Kurukshetra (Fish farm).

(b) *Hypophthalmichthys nobilis* (Richardson) (Fig. 8)

Syns. 1822, *Leuciscus nobilis*, Valenciennes. *Voy H.M.S. "sulphur"*, p. 140, pl. 63, fig. 3.

1984, *Aristichthys nobilis*, Wu. *The Cyprinid fishes of China*, **1**: 223.

1981, *Hypophthalmichthys nobilis*, Howes. *Bull. Br. Mus. nat. Hist.* (Zool.), **41**(1): 2.

1991, *Hypophthalmicthys nobilis*, Talwar and Jhingran. *Inland Fishes*, **1**: 332.

1999, *Hypophthalmicthys nobilis*, Jayaram. *The Freshwater Fishes of The Indian Region*, p. 62.

Fin formula: D. $_{ii-iii/7}$ A. $_{iii/11}$ P. $_{i/19}$ V. $_{i/7-8}$

Common Name: Bighead carp.

External Characters: Body elongated, deep (being 3.5 times in standard length) and compressed; abdomen keeled form ventral fins onward; head large as compared to body, its depth being 4.2 times in standard length; snout short and broad with anterior end obtusely rounded; mouth oblique and terminal, with slightly protruding lower jaw; gill rakers separated, but closely placed, slender and long; dorsal fin short in comparison to body, inserted slightly behind the pelvic fin origin but equidistant from snout-tip and caudal fin base; caudal fin forked; scales small with lateral line having 110-113 scales; lateral transverse scales count 30-32/15-16; pre-dorsal scales 55-60.

Colour: Dorsal side greyish with silvery ventral surface; dorsal, anal and caudal fin studded with minute black spots; pectoral and pelvic fin translucent white.

Location: Sirsa.

Superorder : Ostariophysi
Order : Cypriniformes
Family : Cyprinidae
Subfamily : Rasborinae

Genus: *Amblypharyngodon* Bleeker

1860, *Amblypharyngodon* Bleeker. *Nat. Tijdschr. Ned. Indie.*, **20**: 433.

Body elongated and slightly compressed with rounded abdomen; mouth moderately wide, oblique with prominent lower jaw having symphysial knob, upper lip absent; barbels absent; eyes large, visible from under ventral side; pharyngeal bones having teeth; dorsal fin very short without osseous ray, inserted slightly behind pelvic fin origin and reaching upto anal fin; caudal fin forked; scales very small; lateral line incomplete.

***Amblypharyngodon mola* (Hamilton-Buchanan) (Fig. 9)**

Syns. 1822, *Cyprinus mola*, Hamilton-Buchanan. *Fish. Ganges*, pp. 334, 392, pl. 38, fig. 92.

1878, *Amblypharyngodon mola*, Day. *Fish. India*, p. 555, pl. 135, fig. 4.

1959, *Amblypharyngodon mola*, Misra. *Rec. Indian Mus.*, **57**: 146.

1991, *Amblypharyngodon mola*, Talwar and Jhingran. *Inland Fishes*, **1**: 338.

1999, *Amblypharyngodon mola*, Jayaram. *The Freshwater Fishes of The Indian Region*, p. 86, fig. 54.

Fin formula: D. $_{ii\text{-}iii/7\text{-}8}$ A. $_{ii\text{-}iii/5\text{-}6}$ P. $_{i/13}$ V. $_{i/8}$

Common Name: Makhni.

External Characters: Body elongated with rounded abdomen, its depth being 3.3-3.4 times in standard length; dorsal and ventral profile equally convex; head moderate-sized with blunt or oval snout; eyes large; mouth terminal, oblique with lower jaw extended upward; upper lip absent; inter-orbital space convex; dorsal fin more towards caudal fin base than to snout-tip; anal fin of have same length and depth; caudal fin forked; scales small; lateral line incomplete, ceases after 12-16 scales; 80-85 scales in lateral series; 13-15 scales between lateral line and dorsal fin origin; 9-10 scales between lateral line and pelvic fin base; pre-dorsal scale 36-40.

Colour: Body silvery-white or transparent with golden tinge in living condition; dark silvery band on lateral side of body after preservation in formalin; black spots at the base of dorsal, anal and caudal fins; pectoral and pelvic fins hyaline.

Location: Panchkula (Nada Sahib),Yamunanagar, Ambala.

Genus: *Aspidoparia* Heckel

1843, *Aspedoparia* Heckel.
Fenzl. Abbild. Thiere Pill. Syr. Fische., p. 186.

Body elongated, sub-cylindrical with rounded abdomen; head moderate; sub-orbital bones broad or having moderate width; mouth small and sub-terminal; lower jaw without lip but having a sharp crescentic bony edge; barbels absent; dorsal fin inserted above or slightly behind the pelvic fins base with 9-10 rays and without any osseous ray; anal fin with 10-12 rays; caudal fin forked; scales of moderate size; lateral line concave and passing along the lower half of caudal fin base (caudal peduncle).

***Aspidoparia morar* (Hamilton-Buchanan) (Fig. 10)**

Syns. 1822, *Cyprinus morar*, Hamilton-Buchanan. *Fish. Ganges*, pp. 264, 384, pl. 31, fig. 75.

1878, *Aspidoparia morar*, Day. *Fish. India*, p. 585, pl. 146, fig. 4.

1959, *Aspidoparia morar*, Misra. *Rec. Indian Mus.*, **57**: 147.

1991, *Aspidoparia morar*, Talwar and Jhingran. *Inland Fishes*, **1**: 340, fig. 119.

1999, *Aspidoparia morar*, Jayaram. *The Freshwater Fishes of The Indian Region*, p. 68, fig. 44.

Fin formula: D. $_{ii\text{-}iii/7\text{-}8}$ A. $_{ii\text{-}iii/8\text{-}9}$ P. $_{i/13\text{-}14}$ V. $_{i/7}$

Common Name: Chelluah, Chilwa, Kenwachi, Aspidoparia.

External Characters: Body elongated and sub-cylindrical, its depth being 3.8-4.1 times in standard length; head moderate to its length being 4.5-4.7 times in standard lenght; snout obtuse; mouth sub-terminal, slightly inferior with longer upper jaw overlapping the lower; cheeks covered by a broad sub-orbital ring of bones; supra-orbital process well developed; inter-orbital space convex; dorsal fin with more depth than length, inserted behind pelvic fin base anal fin almost of same length and height; caudal fin deeply emarginated or forked; scales fairly deciduous; lateral line with 38-40 scales; pre-dorsal scales 18-20; lateral transverse scales count 7-8/3-4.

Colour: Body dorsal surface light brown in colour; ventral side yellowish-silvery in appearance; a brown band or burnish streak started from operculum upto the base of caudal fin present; fins yellowish.

Location: Yamunanagar, Panchkula, Karnal, Panipat.

Genus: *Barilius* Hamilton-Buchanan

1822, *Barilius*, Hamilton-Buchanan. *Fish. Ganges*, p. 266, 384.

Body elongated; compressed laterally or sub-cylindrical; head pointed; abdomen; may or may not be rounded; mouth anterior or terminal, not protractile; eyes large, superior, not visible from ventral side in many species; lips thin and simple; lower jaw with poorly developed symphysial knob; barbells four, two or none; dorsal fin without osseous ray and inserted opposite between inter-space of pelvic fin and anal fin, more near to the caudal fin base than to snout;

caudal fin forked; scales small to moderate; lateral line concave, continued on to the middle or lower half of caudal fin (when present), may be incomplete or absent; body usually silvery with dark spots or vertical bands.

Keys to Species

(i) Barbels two. .....(ii)

Barbels four. .....(iii)

(ii) Pectoral axillary scale elongate without a fleshy border; two rows of blotches on belly; barbels rudimentary; lateral line scales 89-92; lower jaw longer than combined length of snout and eye. .....***Barilius bola* syn. *Raiamas bola***

Pectoral axillary scale may be with a fleshy border. .....(iii)

(iii) Lateral line with 50-60 scales; lower jaw shorter or equal to combined length of snout and eye; 12 vertical bars on body. .....***Barilius shacra***

Lateral line with 37-48 scales. .....(iv)

(iv) Anal fin short with 11 rays (8-9 branched), each scale have black spot on posterior part. .....***Barilius bendelisis***

Anal fin long with 10-12 branched rays, scales not spotted. .....(v)

(v) Body with 10-13 small vertical bars above lateral line. .....***Barilius vagra***

Body with 12-15 vertical bands reaching upto the lateral line (in fresh specimens). .....***Barilius barila***

(a) *Barilius barila* (Hamilton-Buchanan) (Fig. 11)

Syns. 1822, *Cyprinus* (*Barilius*) *barila*, Hamilton-Buchanan. *Fish. Ganges*, pp. 267, 384.

1878, *Barilius barila*, Day. *Fish. India*, p. 591, pl. 148, fig. 4.

1959, *Barilius barila*, Misra. *Rec. Indian Mus.*, **57**: 141.

1991, *Barilius barila*, Talwar and Jhingran. *Inland Fishes*, **1**: 343, fig. 120.

1999, *Gudusia chapra*, Jayaram. *The Freshwater Fishes of The Indian Region*, p. 69, pl. 1, fig. 1.

Fin formula : D. $_{ii/7}$ A. $_{iii/10}$ P. $_{i/12}$ V. $_{i/8}$

Common Name: Chilwa, Bhareli, Baril.

External Characters: Body elongated, shallow, compressed laterally; its depth and head length being 4.1-4.4 times in standard length; dorsal profile almost straight; snout pointed; mouth moderate with long jaws (upper jaw slightly extended over lower jaw); lower jaw has symphysial knob that fits into the notch of upper jaw; cleft of mouth reaching below 1/3rd of eye; two pairs of barbels present (short rostral pair and long maxillary pair); inter-orbital space convex; a notch present on the snout; dorsal fin in advance of anal fin; caudal fin forked with slightly longer lower lobe; scales moderate, lateral lint with 42-46 scales; pre-dorsal scales 22; scales between lateral line and dorsal fin origin is 7-8 while the scales between lateral line and pelvic base is 3.

Colour: General body colour silvery; 12-15 diffused blue coloured vertical bands (extending from dorsal side to lateral line) present; tips of dorsal and caudal fin blackish.

Location: Panchkula(Nada Sahib),Yamunanagar, Ambala, Panipat.

(b) *Barilius bendelisis* (Hamilton-Buchanan) (Fig. 12)

Syn. 1807, *Cyprinus bendelisis*, Hamilton-Buchanan. *Journey in Mysore*, **3**: 345.

1822, *Cyprinus* (*Barilius*) *cocsa*, Hamilton-Buchanan. *Fish. Ganges*, pp. 272, 385, pl. 3, fig. 77.

1822, *Cyprinus* (*Barilius*) *chedra*, Hamilton-Buchanan. *Fish. Ganges*, pp. 273, 385, pl. 3, fig.

1878, *Barilius bendelisis*, Day. *Fish. India*, p. 590, pl. 148, figs. 7, 8 and 9.

1959, *Barilius bendelisis*, Misra. *Rec. Indian Mus.*, **57**: 141.

1991, *Barilius bendelisis*, Talwar and Jhingran. *Inland Fishes*, **1**: 346.

1999, *Barilius bendelisis*, Jayaram. *The Freshwater Fishes of The Indian Region*, p. 70.

Fin formula: D. $_{ii-iii/7}$ A. $_{ii-iii/9}$ P. $_{i/13-14}$ V. $_{i/8}$ ... var. *cocsa* (Female)

D. $_{ii/7}$ A. $_{ii-iii/7}$ P. $_{iii-v/10}$ V. $_{i/8}$ ... var. *chedra* (Male)

Common Name: Kanderi, Kunnul, Paktah, Bhareli.**External Characters:** Body elongated with rounded abdomen, its depth being 4.5 times (var. *cocsa*) and 4.2 times (var. *chedra*) in comparision to standard length; head depressed; dorsal profile straight as compared to ventral; head length being 4.8 times of standard length in var. *cocsa* while 3.8 times in var. *chedra*; mouth moderate, terminal with compressed jaws; maxilla large, extends to below the anterior 1/3rd part of th eye-orbit; upper jaw slightly longer than lower; two pairs of barbels (rostral and maxillary) present; rostral pair often absent or rudimentary (if present) in var. *cocsa*; dorsal fin more towards caudal fin base than to snout-tip; scales with moderate size and many radii; lateral line with 43 scales in var. *cocsa* and 54-57 in var. *chedra*; pre-dorsal scales 20-21 in var. *cocsa* and 23-26 in var. *chedra*; pores or tubercles present on snout and lower jaw (poorly developed); pectoral fins (outer 3 rays) thickened in var. *chedra*; lateral transverse scale count 8/3 in var. *cocsa* and 9/5 in var. *chedra*.

Colour: Body colour silvery with slightly geryish dorsal side; lateral line scales have two black spots at their base, while other scales have single black spot at their posterior part; pelvics and anal fin have orange-yellowish tinge while dorsal and caudal fin greyish in fresh specimen.

Location: Yamunanagar, Karnal, Panipat.

(c) *Barilius bola* (Hamilton-Buchanan) syn. *Raiamas bola* (Fig. 13)

Syns. 1822, *Cyprinus bola*, Hamilton-Buchanan. *Fish. Ganges*, pp. 274, 275.

1878, *Barilius bola*, Day. *Fish. India*, p. 594.

1959, *Barilius bola*, Misra. *Rec. Indian Mus.*, **57**: 142.

1991, *Raiamas bola*, Talwar and Jhingran. *Inland Fishes*, **1**: 384, fig. 137.

1999, *Barilius bola*, Jayaram. *The Freshwater Fishes of The Indian Region*, p. 70, pl. 1, fig. 3.

Fin formula: D. $_{ii-iii/7-8}$ A. $_{iii/10}$ P. $_{i/13}$ V. $_{i/8}$

Common Name: Indian trout.

External Characters: Body elongated with rounded abdomen, its depth being 4.5-4.6 times in standard length; ventral profile more convex than dorsal; head moderate, being 3.8 times in standard length with pointed snout; mouth wide, terminal, slightly oblique, cleft extending beyond eyes; maxilla or lower jaw longer than combined length of snout and eye; pectoral axillary scale elongate with a fleshy border; cleft of mouth very deep and reaches the hind edge of eye; well-developed symphysial knob on the lower jaw and corresponding notch on the upper jaw to recieve it; tubercles well developed on lower jaw and snout; maxillary barbels absent or rudimentary (if present); dorsal fin inserted behind the pelvic fin origin; scales small; lateral line slightly curved downward with 89-92 scales; lateral transverse scale count 16/7; pre-dorsal scales 43-45.

Colour: Body colour silvery with greenish-grey dorsal surface to creamy-white belly; longitudinal golden stripes along the flank (in fresh condition); 4-5 vertical rows of bluish spots along the sides; upper two rows with 16-20 bands while the rest rows have 6-10 bands; dorsal fin slightly grey; caudal fin have typical orangish-tinge while other have yellowish.

Location: Yamunanagar.

(d) *Barilius shacra* (Hamilton-Buchanan) (Fig. 14)

Syns. 1822, *Cyprinus* (*Barilius*) *bola*, Hamilton-Buchanan. *Fish. Ganges*, pp. 271, 385.

1878, *Barilius shacra*, Day. *Fish. India*, p. 590, pl. 148, fig. 5.

1991, *Barilius shacra*, Talwar and Jhingran. *Inland Fishes*, **1**: 351, fig. 121.

1999, *Barilius bola*, Jayaram. *The Freshwater Fishes of The Indian Region*, p. 70.

Fin formula: D. $_{ii/7}$ A. $_{ii-iii/8}$ P. $_{i/14}$ V. $_{i/8}$

Common Name: Gurha, Shacra baril.

External Characters: Body elongated, shallow, laterally compressed, its depth being 4.5-4.8 times in standard length; abdomen rounded; head length 4.4 times in standard length; mouth moderate, terminal, oblique with long jaws; maxilla reaches upto anterior margin of eye-orbit; tubercles poorly developed on snout and lower jaw; barbels 4 (rostral pair longer than maxillary); maxillary pair almost equal to eye; dorsal fin inserted behind pelvic fin origin, its last ray being exactly over first anal fin ray; scales small to moderate; lateral line scale 52-57; pre-dorsal scale 22-24.

Colour: Body slightly greyish on dorsal side with silvery on ventral side; 12 vertical bars reaching upto

lateral line from dorsal side; dorsal fin with faint black bands on outer edge.

Location: Panchkula(Nada Sahib), Yamunanagar.

(e) *Barilius vagra* (Hamilton-Buchanan) (Fig. 15)

Syns. 1822, *Cyprinus* (*Barilius*) *vagra*, Hamilton-Buchanan. *Fish. Ganges*, pp. 269, 385.

1878, *Barilius vagra*, Day. *Fish. India*, p. 589, pl. 148, fig. 3.

1959, *Barilius vagra*, Misra. *Rec. Indian. Mus.*, **57**: 143.

1978, *Barilius vagra*, *pakistanicus*, Mirza and Sadiq. *Bilogia*, **24**(1): 1.

1991, *Barilius vagra*, Talwar and Jhingran. *Inland Fishes*, **1**: 353, fig. 123.

1999, *Barilius vagra vagra*, Jayaram. *The Freshwater Fishes of The Indian Region*, p. 70, pl. 1, fig. 5.

Fin formula: D. $_{ii\text{-}iii/7}$ A. $_{ii\text{-}iii/10\text{-}12}$ P. $_{i/14\text{-}15}$ V. $_{i/8}$

Common Name: Chilwa, Vagra baril.

External Characters: Body shallow but elongated, its maximum depth equal to head length being 4.4-4.8 times in standard length; dorsal and ventral profile same; mouth terminal, oblique; jaws long; maxilla extends to below middle of eye-orbit; well developed symphyseal knob in lower jaw and corresponding invagination in the upper jaw; two pairs of barbels present (maxillary pair very shorter than rostral ones), several young ones have 1 pair of barbels in many cases; tubercles poorly developed; dorsal fin inserted ahead of anal fin; its last 1-2 fin rays are over anal fin; anal fin length equal to the maximum height of dorsal fin; pectoral fin shorter than head length; caudal fin forked; scales small to moderate; lateral line with 37-43 scales; pre-dorsal scales 20-22.

Colour: Body silvery with light brown dorsal profile; 10-13 bluish vertical thick bars, ending before lateral line present, clearly distinct in preserved specimens; dorsal and caudal fin have grey margin other fins have yellowish-pink tinge in fresh condition.

Location: Yamunanagar, Panchkula (Nada Sahib), Ambala, Karnal.

Superorder : Ostariophysi

Order : Cypriniformes

Family : Cyprinidae

Subfamily : Cultrinae

Genus: *Chela* Hamilton-Buchanan

1822, *Chela*, Hamilton-Buchanan. *Fish. Ganges*, pp. 258, 383.

Body compressed laterally; abdominal edge cutting or softly keeled below pelvic fin to anal region; head short; snout blunt; mouth oblique, directing upward with prominent lower jaw; cleft not reaching upto eye-orbit; lips thin; barbels absent; dorsal fin inserted slightly behind the anal fin origin; pelvic fin usually with a strongly produced ray and inserted nearer to pectoral fin than to anal fin; caudal fin forked; lateral line curve downwards *i.e.* more towards ventral side; scales moderate in size.

Chela cachius (Hamilton-Buchanan) (Fig. 16)

Syns. 1822, *Cyprinus* (*chela*) *cachius*, Hamilton-Buchanan. *Fish. Ganges*, pp. 259, 384.

1878, *Perilampus atpar*, Day. *Fish. India*, p. 558, pl. 151, fig. 6.

1958, *Chela* (*Chela*) *cachius*, Munro. *J. Bombay nat. Hist. Soc.*, **55**(1): 66. 1991, *Chela cachius*, Talwar and Jhingran. *Inland Fishes*, **1**: 313, fig. 111.

1999, *Chela cachius*, Jayaram. *The Freshwater Fishes of The Indian Region*, p. 73, fig. 45.

Fin formula: D. $_{ii/7\text{-}8}$ A. $_{ii/19\text{-}21}$ P. $_{i/10\text{-}11}$ V. $_{i/5}$

Common Name: Morriah, Kachni.

External Characters: Body greatly compressed, elongated, its depth being 3 times in standard length; abdomen gently keeled only between pelvic fin and anal fin base; ventral profile more convex than dorsal; head moderated being 4.-4.7 times in standard length; mouth terminal, oblique and directed upward; its jaw protractile; no symphysial knob in lower jaw; no barbels; dorsal fin arises behind anal fin origin; outermost ray of pelvic fin strongly produced into a filamentous long ray reaching upto anal fin; lateral line complete with 52-54 moderate-size scales; scales between lateral line and dorsal fin origin 9-12 while between lateral line and pelvic fin base is 4-5; pre-dorsal scales 24-26.

Colour: Body translucent shining silvery with white belly; dorsal side light olive; narrow black-brown streak

running form upper gill opening passing through middle of body upto caudal fin base (visible clearly in preserved condition); fins have yellowish tinge at their bases.

Location: Yamunanagar, Ambala, Karnal, Panchkula (Nada Sahib).

Genus: *Salmostoma* Swainson

1839, *Salmostoma*,Swainson.*Nat.Hist.Fish.*, **2.** 184

Body elongated, laterally compressed; abdomen softly keeled from below pectoral fin to anus; snout blunt or pointed; mouth oblique; its cleft extending upto eye-orbit; eyes large, dorso-lateral in position; sub-orbital bones broad; symphysial knob present on the lower jaw; dorsal fin short and inserted almost opposite or slightly in advance to anal fin; pectoral fins longer than head and with elongate axillary scale; caudal fin deeply forked; scales small, deciduous; lateral line complete and curved downwards above pectoral fin; pre-dorsal scales extends to between eyes.

Keys to Species

(a) Anal fin with 10-12 branched rays; number of scales 5-6 between lateral line and pelvic fin base; lateral line scale 91-103. ..... ***Salmostoma bacaila***

(b) Anal fin with 13-15 branched rays; number of scales 7-8 between lateral line and pelvic fin base; lateral line scales 88-95. ..... ***Salmostoma phulo punjabensis***

(a) *Salmostoma bacaila* (Hamilton-Buchanan) (Fig. 17)

Syns. 1822, *Cyprinus bacaila*, Hamilton-Buchanan. *Fish. Ganges*, pp. 265, 384, pl. 8, fig. 76.

1878, *Chela bacaila*, Day. *Fish. India*, p. 603, pl. 152, fig. 5.

1958, *Oxygaster bacaila*, Misra. *Rec. Indian Mus.*, **57**: 140.

1968, *Salmostoma bacaila*, Banarescu. *Revue Roum. Biol.* (Zool.), **13**(1): 4. 1991, *Salmostoma bacaila*, Talwar and Jhingran. *Inland Fishes*, **1**: 321, fig. 115.

2010, *Salmophasia bacaila*, Jayaram. *The Freshwater Fishes of The Indian Region*, p. 65, fig. 43.

Fin formula: D. $_{ii/7}$ A. $_{iii/12}$ P. $_{i/12}$ V. $_{i/8}$

Common Name: Chilwa, Chelliah, Razor belly minnow.

External Characters: Body elongated, sharply compressed laterally with gently keeled abdomen; its depth being 4.4-5 times in standard length; dorsal profile more concave; head moderate and 4.1-4.6 times in standard length; mouth oblique and superior, its cleft reaches to anterior margin of eyes; sub-orbital bones broad, nearly covering the cheeks; lower jaw with well-developed symphysial knob; dorsal fin situated in the posterior1/3rd of the body well in advance of anal fin; dorsal and anal fin is of almost same height; pectoral fin reaches nearly the base of ventral fin; scales small, fairly deciduous; lateral line more curved towards ventral side with 91-103 scales; lateral transverse scales 17-19/5-6; pre-dorsal scales count 57-65.

Colour: Uniform silvery body with burnish-brown dorsal surface, silvery-white belly; scales dotted black in upper half; shining blue-green band along the flank (visible in fresh specimens only).

Location: All over Haryana.

(b) *Salmostoma phulo punjabensis*(Day) (Fig.18)

Syns. 1872, *Chela punjabensis*, Day. *J. Asiat. Soc. Beng.*, **41**(2): 25; Day, 1978. *Fish. India*, p. 601, pl. 153, fig. 2.

1979, *Salmostoma punjabensis*, Howes. *Bull. Br. Mus. nat. Hist.* (Zool.), **36**(3): 190.

1991, *Salmostoma punjabensis*, Talwar and Jhingran. *Inland Fishes*, **1**: 326.

2010, *Salmophasia phulo punjabensis*, Jayaram. *The Freshwater Fishes of The Indian region*, p. 66.

Fin formula: D. $_{ii/7}$ A. $_{iii/13-15}$ P. $_{i/12}$ V. $_{i/6}$

Common Name: Chilwa, Silvery.

External Characters: Body elongated and laterally compressed, its depth and head length being 4.7 times in standard length; dorsal profile nearly horizontal; ventral profile more convex making body deep; mouth oblique, superior, horizontal and terminal; maxilla extends to nearly beneath the anterior margin of eye; symphysial knob poorly-developed on lower jaw; dorsal fin inserted above the origin of anal fin; body scales small, deciduous; lateral line curves gently from shoulder with 88-96; lateral

transverse scale count 12-14/7-8; pre-dorsal scale count 65-73.

Colour: Body colour uniform silvery with a burnish-silvery band along its flank; cheeks have pinkish tinge in fresh specimens; belly silvery-white.

Location: All over Haryana.

Superorder : Ostariophysi

Order : Cypriniformes

Family : Cyprinidae

Subfamily : Garrinae

Genus: *Crossocheilus* Kuhl et van Hasselt
1823, *Crossocheilus*, Kuhl et van Hasselt. *Algemeine Konst. En Letter-Bode*, **2**(35): 132.

Body fairly long, sub-cylindrical; head small; snout obtusely rounded and overhanging; eyes large; mouth inferior with well-developed upper lip which is continued with lower lip by a fold of skin at the corners of mouth; jaws unequal, narrow; barbels 4 or 2 (if 2, then only rostral pair present); dorsal fin inserted in advance of ventral fin; caudal fin forked; scales moderate-sized; lateral line complete.

***Crossocheilus latius diplocheilus* (Heckel) (Fig. 19)**

Syns. 1838, *Barbus diplocheilus*, Heckel. *Fische. Aus. Caschmir.*, p.53, pl.10, fig.1.

1877, *Cirrhina latia*, Day. *Fish. India*, p. 548.

1934, *Crossocheilus latius punjabensis*, Mukerji. *J. Bombay Nat. Hist. Soc.*, **37**(1): 53, fig. 7.

1991, *Crossocheilus latius diplocheilus*, Talwar and Jhingran. *Inland Fishes*, **1**: 415, fig. 145.

1999, *Garra gotyla gotyla*, Jayaram. *The Freshwater Fishes of The Indian region*, p. 152.

Fin formula: D. $_{iii-iv/8}$ A. $_{ii/5}$ P. $_{i/13}$ V. $_{i/8}$

Common Name: Behrah, Tellaree, Kashmir latia.

External Characters: Body elongate, sub-cylindrical, its depth being 4.1 to 4.7 times in standard length; head more flat compressed dorso-ventrally, its length being 4.5-4.8 times in standard length; eyes moderate-sized, being 3.2-3.7 times in head length; mouth inferior, with a narrow frenulum connecting upper with lower jaw; barbels 4 (2 rostral and 2 maxillary), rostral barbels being very short; scales moderate; dorsal fin inserted nearer to snout-tip than to caudal fin base; pectorals and pelvics horizontally present; caudal fin forked; scales moderate-sized; lateral line scales 37-39; pre-dorsal scale count 9-10; lateral transverse scales 5-6/4-5.

Colour: Body colour greyish-black on dorsal side with dark blotches in the form of irregular patches all over the body; ventral side dirty-white with rough black spots (not so concentrated as on dorsal side); a faint black longitudinal stripe on flank; dorsal and anal fin have greyish-black tip; all fins dark spotted.

Location: Panchkula (Nada Sahib).

Genus: *Garra* Hamilton-Buchanan
1822, *Garra*, Hamilton-Buchanan. *Fish. Ganges*, pp. 343, 393.

Body elongated, sub-cylindrical, with head and body flattened on their ventral surface; mouth transverse, inferior or sub-terminal and semicircular; upper and lower lips continuous, no lateral lobes; a suctorial-disc on chin formed by modification of lower lip; upper lip fringed and continuous with lower lip; jaws unequal; barbels generally 4, 2 or absent; dorsal fin inserted near to snout than to caudal fin and with few hard rays; pectoral and pelvic fins are horizontal placed; caudal fin forked; scales of moderate-size, cycloid; lateral line distinct and complete with 32-36 scales.

***Garra gotyla gotyla* (Gray) (Fig. 20)**

Syns. 1832, *Cyprinus gotyla*, Gray. *Illustr. Indian Zool.*, **1**: pl. 88, fig. 3.

1877, *Discognathus lamta*, Day. *Fish. India*, p. 527, pl. 123, fig. 1.

1964, *Garra gotyla gotyla*, Menon. *Mem. Indian Mus.*, **14**(4): 233, pl. 13, figs. 1-4.

1991, *Garra gotyla gotyla*, Talwar and Jhingran. *Inland Fishes*, **1**: 421.

1999, *Garra gotyla gotyla*, Jayaram. *The Freshwater Fishes of The Indian region*, p. 154.

Fin formula: D. $_{iii.7-8}$ A. $_{ii/5}$ P. $_{i/14}$ V. $_{i/8}$

Common Name: Kurka, Gotyla.

External Characters: Body elongate, sub-cylindrical, flat on the ventral surface and convex on

the dorsal side, its maximum depth being 4.3-5.0 times standard length; head blunt and depressed, its length being3.8-4.0 times in standard length; eyes small; inter-orbital region convex; several spiny tubercles on snout; mouth inferior, semi-circular or arched; upper lip fringed; lower lip modified to form *suctorial-disc* on the ventral side of head; barbels 4 (2 rostral and 2 maxillary), minute pairs; dorsal fin inserted in advance of ventral fin; pectoral and pelvic fins horizontal; pectoral fin equal to or shorter than head length; scales moderately-sized; lateral line with 33-34 scales; lateral transverse scales 4-5/3-4; pre-dorsal scales count 9-10; breast and belly also having scales.

Colour: Body earthen-green mixed with grey, light pink or dull green belly; faint spot on either side towards end of caudal peduncle at caudal fin base; row of dark spots on the base of dorsal fin also (clearly visible in fresh specimens).

Location: Panchkula (Nada Sahib), Yamunanagar.

Superorder : Ostariophysi

Order : Cypriniformes

Family : Cyprinidae

Subfamily : Cyprininae

Genus: *Catla* Valenciennes

1844, *Catla*, Valenciennes. *Hist. Nat. Poss.*, **18**: 410.

Body short and broad with large prominent head and rounded abdomen; snout bluntly rounded; eyes large, ventro-lateral in position and easily visible below the head; mouth wide and terminal; upper lip absent, lower lip very thick with a continuous and free posterior margin; barbels absent; pharyngeal teeth in 3 rows; gill rakers rather long, closely set; eyes with free orbital margin; dorsal fin long with larger base; pectoral fin tip reaching pelvic fin; caudal fin deeply emarginate or forked; scales large-sized with lateral line having 40-42 scales.

***Catla catla* (Hamilton-Buchanan) (Fig. 21)**

Syns. 1822, *Cyprinus catla*, Hamilton-Buchanan. *Fish. Ganges*, pp. 287, 318, pl. 13, fig. 81.

1878, *Catla buchanani*, Day. *Fish. India*, p. 533, pl. 134, fig. 5.

1959, *Catla catla*, Misra. *Rec. Indian. Mus.*, **57**: 156.

1991, *Catla catla*, Talwar and Jhingran. *Inland Fishes*, **1**: 163, fig. 62.

1999, *Catla catla*, Jayaram. *The Freshwater Fishes of The Indian Region*, p. 131, fig. 73.

Fin formula: D. $_{iii/15}$ A. $_{iii/5}$ P. $_{i/17-18}$ V. $_{i/8}$

Common Name: Catla, Thaila, Thail.

External Characters: Body deep, its depth 2.9-3.0 times in standard length; head enormously large; mouth upturned with prominent protruding lower jaw; lower jaw have imperfect symphysial articulation with upper jaw (without a knob); lips thick, especially the lower one; snout blunt with slight depression near nostrils; inter-orbital space convex; barbels absent; dorsal fin origin more towards snout-tip, inserted slightly in advance of pelvic fins (its origin more towards snout-tip than to caudal fin base), having long base with 18 rays (15 branched and soft-ray and 3 non-osseous, unbranched hard-ray); anal fin with 8 rays (5 branched); pectoral fins quite long reaching upto pelvic fin origin; caudal fin forked; scales conspicuously large-sized; lateral line with 40-42 scales; pre-dorsal scale count 13-14; lateral transverse scales $8/7^{1/2}$.

Colour: General body colour silvery, with greenish-grey dorsal side and silvery-white ventral; fins dotted black, denser at their edges; those inhabiting stagnant turbid water have more darker appearance.

Location: All over Haryana.

Genus: *Chagunius* Smith

1938, *Chagunius*, Smith. *Proc. Biol. Soc. Washington*, **15**: 157.

Body elongated, moderately compressed with rounded abdomen; head laterally compressed; eyes large, superior; cheeks deep and tuberculated; snout slightly overhanging on barbels; mouth narrow, sub-terminal; lips thick and fleshy, papillated; post-labial groove incomplete; barbels 2 pairs (rostral and maxillary), well-developed; dorsal fin with 13 rays (7-8 branched) with anterior ray cultrate i.e. highly serrated towards its inner side; caudal fin forked; scales medium-sized, diamond-shaped, with many radii; lateral line with 46-48 scale.

***Chagunius chagunio* (Hamilton-Buchanan) (Fig. 22)**

Syns. 1822, *Cyprinus chagunio*, Hamilton-Buchanan. *Fish. Ganges*, pp. 395, 387.

1877, *Barbus chagunio*, Day. *Fish. India*, p. 559, pl. 136, fig. 1.

1940, *Barbus* (*Chagunius*) *chagunio*, Hora and Gupta. *J. Asiat. Soc. Beng.*, **6**(2): 79.

1991, *Chagunius chagunio*, Talwar and Jhingran. *Inland Fishes*, **1**: 167, fig. 63.

1999, *Chagunius chagunio*, Jayaram. *The Freshwater Fishes of The Indian Region*, p. 107, fig. 65.

Fin formula: D. $_{v/7-8}$ A. $_{iii/5}$ P. $_{i/15}$ V. $_{i/8}$

Common Name: Galehri, Chaguni.

External Characters: Body elongated, compressed laterally with rounded abdomen; body depth more or less equal to the head length being 3.8-3.9 times in standard length; mouth narrow and sub-terminal; barbels 4 (2 rostral and 2 maxillary), longer than eye-orbit; eyes large; tubercles present on snout and cheeks; dorsal fin inserted ahead of pelvic fin origin with 1st dorsal spine strong and osseous with many denticulations towards its inner surface; anal fin base length half of its height; caudal fin forked; scales moderate with many visible radii; lateral line complete having 46-47 scales; lateral transverse scales 11/6-7; pre-dorsal scales 14.

Colour: Body colour silvery; accentuated black spots on scales margin; caudal and anal fins pinkish or reddish on their outer margins (in fresh specimens); dorsal fin black-edged; random crescentic streaks along the upper part of body, more pronounced in the preserved condition.

Location: Yamunanagar, Karnal.

Genus: *Cirrhinus* Oken

1817, *Cirrhinus* (Oken), Cuvier. *V. Kl. Fische*. In: *Isis Order Encylopadische Zeituny*, **8**: 113.

Body moderately elongated, compressed; abdomen rounded; head short as compared to body length; snout depressed, obstusely rounded; eyes moderate; mouth transverse and wide; lower jaw with mandibular symphysial knob; upper lip fringed or smooth, not continuous with lower lip around the corners; barbels 4, 2 or none and small; pharyngeal teeth in three rows; dorsal fin inserted more towards snout-tip than to caudal fin base; caudal fin deeply emarginated or forked; scales moderate, cycloid; lateral line complete with 36-45 scales.

Keys to Species

(a) Barbels one pair, very short well developed; dorsal fin with 8 branched rays; 36-38 scales. ..... ***Cirrhinus reba***

(b) Barbels short rostral pair only; dorsal fin with 12-13 branched rays; lateral line 43-45 scales. ..... ***Cirrhinus mrigala***

(a) *Cirrhinus mrigala* (Hamilton- Buchanan) (Fig. 23)

Syns. 1822, *Cirrhinus mrigala*, Hamilton-Buchanan. *Fish. Ganges*, pp. 279-386, pl. 6, fig 79.

1877, *Cirrhina mrigala*, Day. *Fish. India*, p. 547, pl. 129, fig. 4.

1959, *Cirrhina mrigala*, Misra. *Rec. Indian Mus.*, **57**: 157.

1991, *Cirrhinus mrigala mrigala*, Talwar and Jhingran. *Inland Fishes*, **1**: 172, fig. 65.

1999, *Cirrhinus mrigala*, Jayaram. *The Freshwater Fishes of The Indian Region*, p. 130.

Fin formula: D. $_{iii-iv/12-13}$ A. $_{iii/5}$ P. $_{i/17}$ V. $_{i/8}$

Common Name: Mrigal, Mori, Marakhi, Murakh.

External Characters: Body streamlined, cylindrical, its depth more than or equal to head-length being 4.2-4.3 times in standard length; mouth transverse and broad; upper lip entire or smooth, lower lip not distinctively visible; pores present on snout; eyes moderate to large; only rostral pair of barbels present; dorsal fin height almost equal to maximum body width; length of pectoral fin is equal to pelvic fin; caudal fin forked; scales moderate-sized; lateral line with 43-45 moderate-sized scales; lateral transverse scale-rows 6-7/6; pre-dorsal scales 15-16.

Colour: Body colour, silvery with dark grey dorsal surface, silvery-white ventral side; eyes golden; fins tinged reddish-orange (especially ventrals, anal and caudal fin) in fresh specimens.

Location: All over Haryana.

(b) *Cirrhinus reba* (Hamilton- Buchanan) (Fig. 24)

Syns. 1822, *Cirrhinus reba*, Hamilton-Buchanan. *Fish. Ganges*, pp. 280-386.

1877, *Cirrhina reba*, Day. *Fish. India*, p. 549, pl. 130, fig. 3.

1959, *Cirrhina reba*, Misra. *Rec. Indian Mus.*, **57**: 158.

1991, *Cirrhinus reba*, Talwar and Jhingran. *Inland Fishes*, **1**: 173.

1999, *Cirrhinus reba*, Jayaram. *The Freshwater Fishes of The Indian Region*, p. 130.

Fin formula: D. $_{iii/8}$ A. $_{iii/5}$ P. $_{i/15}$ V. $_{i/8}$

Common Name: Mori, Sunni, Chunni, Dumra, Reba.

External Characters: Body fairly elongated, streamlined, sub-cylindrical with rounded abdomen; its depth being 3.6-4.0 times in standard length which is slightly more than head-length; dorsal profile slightly more convex (especially near the shoulder); snout having depression and slightly projecting; mouth broad, inferior; upper lip smooth or fringed and having symphysial knob; eyes moderate; inter-orbital space convex; barbels very short, rostral pair only; dorsal fin height less than body depth; caudal deeply forked; scales almost hexagonal in shape, moderate and deciduous in nature; lateral line with 36-38 scales; pre-dorsal scales 12-13; lateral transverse scale rows $7^{1/2}/6$.

Colour: Body colour silvery with irregular longitudinal stripes formed by the edges of the scales; dorsal side greyish; fins (anal and pelvic) orange-tipped generally; dorsal and caudal fins have dusky margins.

Location: Panchkula(NadaSahib), Yamunanagar, Ambala.

Genus: *Ctenopharyngodon* Steindachner

1866, *Ctenopharyngodon*, Steindachner. *Verh. Zool. Bot. Ges. Wein.*, **16**: 782.

Body elongated, streamlined, sub-cylindrical with broad, depressed head with rounded abdomen; operculum large; eyes large, dorso-laterally placed, mostly not visible from underside of head; mouth terminal; lips thin; upper lip has a horizontal covering of rostral fold at its base; post labial groove at the corners of the mouth present; barbels absent; pharyngeal teeth in two rows; dorsal fin inverted slightly opposite to or anterior of pelvic fin with 10 fin rays (7 branched); anal fin with 11-12 rays (8 branched); caudal fin deeply emarginate or forked; scales moderate to large sized and cycloid; lateral line complete.

Ctenopharyngodon idellus (Valenciennes) (Fig. 25)

Syns. 1844, *Leuciscus idella*, Valenciennes. *Hist. Nat. Poiss.*, **17**: 362.

1981, *Ctenopharyngodon idellus*, Howes. *Bull. Brit. Mus. Nat. Hist. (Zool.)*, **41**(1): 40 fig. 30a.

1991, *Ctenopharyngodon idellus*, Talwar and Jhingran. *Inland Fishes*, **1**: 175, fig. 66.

1999, *Ctenopharyngodon idellus*, Jayaram. *The Freshwater Fishes of The Indian Region*, p. 90, fig. 55.

Fin formula: D. $_{iii/7}$ A. $_{iii/8-9}$ P. $_{i/17}$ V. $_{i/8}$

Common Name: Grass carp.

External Characters: Body elongated, sub-cylindrical with dorsal and ventral profile equally arched having depth 3.9-4.2 times in standard length; head broad, depressed, its length being 3.3-3.6 times in standard length with obtusely rounded snout; mouth terminal to sub-terminal, its cleft not reaching eye-orbit; eyes large, dorso-lateral in position; lips thin; dorsal fin more towards snout-tip than to caudal fin base with its base twice as long as its height; caudal fin deeply emarginate or forked; scales moderate to large sized; lateral line slightly curved with 38-41 scales, pre-dorsal scales 17-18; lateral transverse scales 6/5.

Colour: Body colour greyish-green on the dorsal side, silvery on the ventral side; scales darker at their margins; fins dark coloured in fresh specimens.

Location: Yamunanagar, Ambala.

Genus: *Cyprinus* Linnaeus

1758, *Cyprinus* Linnaeus. *Systema Naturae*, ed. X, **1**: 320.

Body stout, robust anteriorly and laterally compressed with rounded abdomen; head moderate and tapering; snout obtuse or bluntly rounded; mouth terminal but oblique with short cleft; barbels 4 (one pair each of rostral and maxillary); pharyngeal teeth in three rows; lips thick and fleshy; dorsal fin have a very long base and inserted midway between snout tip and base of caudal fin, dorsal spine undivided and slightly serrated posteriorly; pectoral fin spatulate; anal fin short; caudal fin deeply emarginate or forked; scales moderate to large, cycloid; lateral line complete.

Keys to Species

(a) Body fully covered with regularly arranged rows of scales; lateral line conspicuous with 32-34 scales. .....

.....***Cyprinus carpio*** var. ***Communis***

(b) Body have unevenly arranged, large and bright scales; lateral line has 17-18 scales in longitudinal series. .....

.....***Cyprinus carpio*** var. ***Specularis***

(a) *Cyprinus carpio communis* Linnaeus(Fig.26)

Syns. 1758, *Cyprinus carpio*, Linnaeus. *Systema Naturae*, (ed. 10), **1**: 320.

1918, *Cyprinus carpio intha*, Annandale. *Rec. Indian Mus.*, **14**(1): 47.

1991, *Cyprinus carpio*, Talwar and Jhingran. *Inland Fishes*, **1**: 184.

1999, *Cyprinus carpio communis*, Jayaram. *The Freshwater Fishes of The Indian Region*, p. 91, fig. 56.

Fin formula: D. $_{iii-iv/18}$ A. $_{iii/5}$ P. $_{i/14-15}$ V. $_{i/8}$

Common Name: Common carp, Scale carp, Golden.

External Characters: Body stout, deep, robust anteriorly and compressed laterally, its depth 2.5-2.8 times in standard length; head moderate, its length being 2.8-3.3 times in standard length; abdomen rounded; dorsal profile more arched than ventral; head moderate; mouth obtuse and directed forward, tapering and protrusible; two pairs of barbels, rostral pair shorter (2/3rd in length) than maxillary barbels; eyes large; dorsal fin very long reaching upto end of anal fin; last dorsal fin ray undivided and serrated behind; pectoral fins very long, reaching upto the base of pelvic fin; pelvic fin equidistant from pectorals and anal fin; caudal fin forked or deeply emarginated; scales large and regularly arranged in rows; lateral line straight and complete with 32-34 scales; lateral line transverse scale count 5/5; pre-dorsal scales 10.

Colour: Body silvery in young with slightly greyish dorsal side which becomes more evident when fishes grows to maturity; gravid fish have darker body colour along with their fins (especially females); older fish have orange tinged scales (hence got its name '*Golden*' by locals); caudal, pelvic and anal fins also have orange-yellow tinge on maturity; scales become darker during breeding season.

Location: Yamunanagar, Ambala, Kurukshertra (Fish Farm).

(b) *Cyprinus carpio specularis* Lecepede (Fig.27)

Syns. 1758, *Cyprinus carpio*, Linnaeus. *Systema Naturae*, ed. X, **1**: 320

1959, *Cyprinus carpio*, Misra. *Rec. Indian Mus.*, **57**: 158.

1991, *Cyprinus carpio*, Talwar and Jhingran. *Inland Fishes*, **1**: 185.

1999, *Cyprinus carpio communis*, Jayaram. *The Freshwater Fishes of the Indian Region*, p. 91.

Fin formula: D. $_{iii-iv/18-19}$ A. $_{iii/5}$ P. $_{i/15}$ V. $_{i/8}$

Common Name: Mirror carp.

External Characters: This fish corresponds similar to var. *communis* in almost all respect except the arrangement of fins on the body. The scales are uneven and irregularly arranged with incomplete lateral line (having 17-18 scales approx. in lateral series). The scales are bigger in size and has shiny surface; barbels 2 pairs (maxillary pair twice in length as that of rostral); lateral transverse scales count 3/2 due to irregular presence of scale and pre-dorsal scales 8-9; body slightly elongated than var. *communis*, its depth being 3.4 times in standard length.

Colour: Body silver coloured on lateral and ventral side; caudal, pelvic and anal fins with orange-red tinge during breeding season; scales have darker margins during breeding period.

Location: Cultured at Fish Farms in Haryana.

Genus: *Labeo* Cuvier

1817, *Labeo*, Cuvier. *Regne Animale*, 2(ed.1):194

Body cylindrical, elongated or deep, with rounded abdomen; mouth narrow, sub-terminal or inferior and protractile; snout rounded, generally overhanging and sometimes having lateral lobes and covered with tubercles; eyes dorso-lateral in position, not visible from underside of head; lips thick, fringed, covering both jaws and continuous at the corners of mouth by labial folds; barbels present, (one or two pairs), generally one maxillary pair present under labial folds;

pharyngeal teeth in three rows; dorsal fin origin always ahead of pelvic fins and devoid of spine; caudal fin forked; scales small to moderate and cycloid; lateral line complete.

Keys to Species

(i) Barbels two pair. .....(ii)

Barbels one pair. .....(iv)

(ii) Dorsal fin rays above 15. .....(iii)

Dorsal fin rays below 15. .....(iv)

(iii) Mouth distinctively inferior and wide; body deep; scales have buff-pink or scarlet spots margins;fins black..... .....***Labeo calbasu***

Mouth sub-terminal and narrow; body oblong or elongated; fins pale. .....(iv)

(iv) Lateral line 40-44; dorsal fin ray 16-17..... .....***Labeo rohita***

Lateral line 39-42; dorsal fin ray 11-12. ....***Labeo angra***

(v) A distinct notch on the snout ....***Labeo dero***

No distinct notch present on snout. .....(vi)

(vi) Body colour silvery; eyes large as compared to head length; lips thin; a small tubercle on the mandibular symphysis of lower jaw; black spot on 5^{th}-6^{th} lateral line scales. .....***Labeo bata***

Body colour dull green; eyes small as compared to head; lips thick, no tubercle; no tubercle on the symphysis of lower jaw; no black spot on 5^{th}-6^{th} lateral line scale. .....***Labeo dyocheilus***

***(a) Labeo angra* (Hamilton- Buchanan) (Fig. 28)**

Syns. 1822, *Cyprinus angra*, Hamilton-Buchanan. *Fish. Ganges*, pp. 331-391.

1877, *Labeo angra*, Day. *Fish. India*, p. 541, pl. 128, fig. 2.

1991, *Labeo angra*, Talwar and Jhingran. *Inland Fishes*, **1**: 198.

1999, *Labeo angra*, Jayaram. *The Freshwater Fishes of The Indian Region*, p. 133.

Fin formula: D. $_{ii-iii/9-10}$ A. $_{ii/5}$ P. $_{i/14-15}$ V. $_{i/8}$

Common Name: Buttar.

External Characters: Body oblong, narrow or elongated, its depth being 4.2-5.0 times in standard length; ventral side slightly cylindrical and less convex as compared to dorsal side; snout overhanging the mouth making it inferior; pores present on snout; eyes large; lips fimbriated; barbels present, maxillary pair only, very short, concealed under labial fold; dorsal fin more towards snout-tip then to caudal fin; pectoral and pelvic fin equal in length; pelvics equidistant form pectorals and anal fin; caudal fin deeply forked; scale moderate with many radii; lateral line with 39-42 scales; lateral transverse scales count 8/5-6; pre-dorsal scales 13-14.

Colour: Body dorsal side steel-grey in colour; silvery-white at the belly; dorsal fin tip black; dusky blotch at the base of caudal fin in fresh condition; a bluish stripe starting from eyes upto caudal fin base passing through flank.

Location: Yamunanagar (Dadupur Headworks), Karnal, Panchkula

(b) *Labeo bata* (Hamilton-Buchanan) (Fig. 29)

Syns. 1822, *Cyprinus bata*, Hamilton-Buchanan. *Fish Ganges*, pp. 283, 386.

1877, *Labeo bata*, Day. *Fish. India*, p. 542, pl. 129, fig. 5.

1959, *Labeo bata*, Misra. *Rec. Indian Mus.*, **57**: 159.

1977, *Labeo bata*, Murthy. *Proc. Indian Acad. Sci.*, **85**B (3): 134.

1991, *Labeo bata*, Talwar and Jhingran. *Inland Fishes*, **1**: 199, fig. 72.

1999, *Labeo bata*, Jayaram. *The Freshwater Fishes of The Indian Region*, p. 133.

Fin formula: D. $_{ii-iii/10}$ A. $_{iii/5}$ P. $_{i/15-16}$ V. $_{i/8}$

Common Name: Morah, Bhangan, Bata.

External Characters: Body elongated, having more convex dorsal side then ventral, its depth being 3.9-4.6 times in standard length; head moderate, its length being 3.7-4.2 times in standard length; snout conical and projecting over mouth with distinct lateral lobes on each side of mouth, often covered with pores; lips thin, continuous at corners; lower lip fringed and with a shallow groove along its hind edge; a tubercle at the symphysis of the lower jaw; no horny coverings inside the jaws; one pair of maxillary barbels only,

rudimentary in size; visible notch over the snout; dorsal fin inserted more near to snout-tip than to caudal fin base; scales moderate sized; lateral line straight with 39-42 scales; lateral transverse scales count 8-9/5-6; pre-dorsal scales 12-13.

Colour: Body greyish-black on the dorsal side, silvery on flank and belly; fins pale and dotted black; a black blotch or spot on 5th-6th lateral line scales (clearly visible in preserved specimens, faint when fresh); faint black spot on caudal peduncle also (in young specimens); pelvic and anal fins with orange-red tips.

Location: Panchkula (Nada Sahib), amunanagar, Ambala, Karnal, Panipat.

(c) *Labeo calbasu*(Hamilton-Buchanan) (Fig. 30)

Syns. 1822, *Cyprinus calbasu*, Hamilton-Buchanan. *Fish Ganges*, pp. 297, 387, pl. 2, fig. 33.

1877, *Labeo calbasu*, Day. *Fish. India*, p. 536, pl. 126, fig. 4.

1921, *Labeo calbasu*, Hora. *Rec. Indian Mus.*, **22**(3): 182.

1959, *Labeo calbasu*, Misra. *Rec. Indian Mus.*, **57**: 161.

1991, *Labeo calbasu*, Talwar and Jhingran. *Inland Fishes*, **1**: 203, fig. 74.

1999, *Labeo calbasu*, Jayaram. *The Freshwater Fishes of The Indian Region*, p. 133, pl. 7, fig. 2.

Fin formula: D. $_{iii/14-16}$ A. $_{ii-iii/5}$ P. $_{i/16-18}$ V. $_{i/8}$

Common Name: Kalbans, Kalbasu.

External Characters: Body elongated and deep; head large, conical, its length less then the body depth; snout with pores but devoid of lateral lobes, depressed; mouth wide, inferior with flat inter-orbital space; eyes moderate; lips thick and fringed (especially lower one), each with a distinct inner fold covered by cartilagenous covering; barbels 4 (rostral pair slightly longer than maxillary); dorsal fin long and inserted midway between snout tip and base of caudal fin with 13-16 fin rays (branched); caudal fin deeply forked; scales moderate; lateral line with 40-45 scales; pre-dorsal scales 16-18; lateral transverse scale count $7^{1/2}/6^{1/2}$.

Colour: Body colour slate grey or greyish-green above lateral line (more on dorsal side) ventral surface silvery or dirty white; flank scales have buff pink or scarlet spots at their edges; fins grey with darker edges; only upper lobe of caudal fin white-tipped

Location: Yamunanagar (Dadupur Headworks), Karnal.

(d) *Labeo dero* (Hamilton-Buchanan) (Fig. 31)

Syns. 1822, *Cyprinus dero*, Hamilton-Buchanan. *Fish Ganges*, pp. 277, 385, pl. 22, fig. 78.

1877, *Labeo diplostomus*, Day. *Fish. India*, p. 540, pl. 129, fig. 2.

1936, *Labeo dero*, Hora and Mukerjee. *Rec. Indian Mus.*, **38**: 133-144.

1959, *Labeo dero*, Misra. *Rec. Indian Mus.*, **57**: 161.

1991, *Labeo dero*, Talwar and Jhingran. *Inland Fishes*, **1**: 204 .

1999, *Labeo dero*, Jayaram. *The Freshwater Fishes of The Indian Region*, p. 133.

Fin formula: D. $_{ii/10}$ A. $_{ii-iii/5}$ P. $_{i/16-17}$ V. $_{i/8}$

Common Name: Gid, Bhanga.

External Characters: Body elongated, deep, its depth being 4.3 times in standard length; dorsal profile more sharp than ventral; head slightly moderate being 3.8-3.9 times in standard body length; snout very prominent with horny tubercles and pores, overhanging and has a distinct deep groove or depression across it; mouth inferior; lips thick, continuous with labial fold; lower lip studded with tubercles; barbels small, maxillary pair only; dorsal fin inserted near to snout-tip than to caudal fin base and midway between snout tip and anal fin base; pelvic and anal fin rays (1st and 2nd) have characteristic wavy appearance; caudal fin forked; scales moderate; lateral line scales 42-44; lateral transverse scales 8/7; pre-dorsal scales count 17-19.

Colour: Body greyish-brown on dorsal side with silvery-grey on sides and belly; fins dark with faint reddish appearance in fresh condition; dorsal fin tip dusky.

Location: Panchkula (Nada Sahib), Ambala, Yamunanagar, Karnal, Panipat.

(e) *Labeo dyocheilus* (McClelland) (Fig. 32)

Syns. 1822, *Cyprinus (Labeo) dyocheilus*, McClelland. *Asiat. Res.*, **19**(2): 268, 330.

1877, *Labeo dyocheilus*, Day. *Fish. India*, p. 540, pl. 130, fig. 1.

1936, *Labeo dyocheilus*, Hora. *Rec. Indian Mus.*, **38**(3): 320.

1976, *Labeo dyocheilus Pakistanicus*, Mirza and Awan. *Biologia*, **22**(1): 43.

1991, *Labeo dyocheilus*, Talwar and Jhingran. *Inland Fishes*, **1**: 207, fig. 75.

1999, *Labeo dyocheilus dyocheilus*, Jayaram. *The Freshwater Fishes of The Indian Region*, p. 134.

Fin formula: D. $_{ii-iii/10}$ A. $_{ii/5}$ P. $_{i/16-17}$ V. $_{i/8}$

Common Name: Konti, Kunni, Buteal, Dhai.

External Characters: Body elongated, deep (depth being 3.6-3.8 times in standard length) with conical or projecting snout having prominent tubercles or pores and distinct lateral lobes; head moderate, its length being 4.2 times in standard length; mouth wide, inferior; lips thick, not fringed; eyes small; lower lip interrupted; both lips fimbriated; horny inner covering on both jaws; barbels 2, very small, maxillary pair only, concealed under labial fold; dorsal fin inserted more towards snout-tip than to caudal fin base; pelvic fins equidistant from pectoral fins and anal fin; caudal fin forked; scales moderate; lateral line scale count 42-43; pre-dorsal scales 13; lateral transverse scales count $7^{1/2}$/5-6.

Colour: Body dull-green with darker dorsal side in fresh specimens; scales and fins dotted black.

Location: Yamunanagar.

(f) *Labeo rohita* (Hamilton-Buchanan) (Fig. 33)

Syns. 1822, *Cyprinus rohita*, Hamilton-Buchanan. *Fish Ganges*, pp. 301, 388, pl. 36, fig. 85.

1877, *Labeo rohita*, Day. *Fish. India*, p. 538, pl. 127, fig. 4.

1948, *Labeo rohita*, Macdonald. *J. Bombay Nat. Hist. Soc.*, **44**: 527.

1959, *Labeo rohita*, Misra. *Rec. Indian Mus.*, **57**: 162.

1991, *Labeo rohita*, Talwar and Jhingran. *Inland Fishes*, **1**: 19, fig. 78.

1999, *Labeo rohita*, Jayaram. *The Freshwater Fishes of The Indian Region*, p. 134, pl. 7, fig. 6.

Fin formula: D. $_{iii/13-14}$ A. $_{iii/5}$ P. $_{i/17}$ V. $_{i/8}$

Common Name: Rohu, Dhamra, Tapra.

External Characters: Body moderately elongated, its depth being 3.2-3.7 times in standard length; dorsal profile more convex than ventral; head very conspicuous in shape, its length being 2.5-3.3 times in standard length; snout rounded or obtuse, slightly depressed and projects beyond the jaws and devoid of pores and lateral lobes; eyes large, its diameter being 4.5-5.3 times the head length; mouth small, narrow and inferior; lips thick and fringed with distinct labial folds; barbels one pair, small, maxillary only, under labial folds; dorsal fin is of same length and width and inserted equidistant from snout-tip and caudal fin base; pectorals and pelvics are of same length; caudal fin forked; scales moderate; lateral line scales 40-44; pre-dorsal scales 15; lateral transverse scales count $7/6^{1/2}$.

Colour: Body slate-black on the dorsal side; with silvery abdomen; cheeks have golden-yellow marks; caudal, anal and pelvic fins orange-red tinged; stagnant water specimens have greenish-black tinge on the dorsal side.

Location: All over Haryana.

Genus: *Osteobrama* Heckel

1843, *Osteobrama*, Heckel. *Icth. Russengger's Reisen in Europe, Asian and Africa*, **1** (1): 1033.

Body short, stout, fairly deep and laterally compressed; abdominal edge sharp and keeled; head short with blunt-snout; mouth terminal directing forward; lips thin, non-fimbriated; mouth upper jaw slightly projecting; barbels 4, 2 and none; eyes large, lateral, visible below the head; dorsal fin short having an osseous serrated spine present opposite the inter-space between pelvic and anal fins; anal fin quite long; lateral line complete; caudal fin deeply forked; scales small to moderate; lateral line complete.

***Osteobrama cotio cotio* (Hamilton-Buchanan) (Fig. 34)**

Syns. 1822, *Cyprinus cotio*, Hamilton-Buchanan. *Fish Ganges*, pp. 339, 393, pl. 39, fig. 93.

1878, *Rohtee cotio*, Day. *Fish. India*, p. 587, pl. 151, fig. 1.

1940, *Rohtee cotio*, Hora and Misra. *Rec. Indian Mus.*, **57**: 164.

1959, *Osteobrama cotio*, Misra. *Rec. Indian Mus.*, **57**: 164.

1991, *Osteobrama cotio*, Talwar and Jhingran. *Inland Fishes*, **1**: 238.

1999, *Labeo calbasu*, Jayaram. *The Freshwater Fishes of The Indian Region*, p. 101.

Fin formula: $D._{iii-iv/8}$ $A._{iii/29-31}$ $P._{i/12-13}$ $V._{i/8}$

Common Name: Sheesha Machhi.

External Characters: Body stout, very deep (2.6-2.7 times in standard length) and very compressed; head moderate, oval, its length being 3.4-4.5 times in standard length; snout blunt and slightly rounded; mouth small and terminal; upper jaw slightly projected; depression on the inter-orbital space; eyes moderate; barbels absent; dorsal profile concave over nape and more pronounced from nape upto origin of dorsal fin; abdominal edge keeled between pelvic and anal fins; dorsal hard ray weak and posteriorly serrated; teeth absent on jaws; scales small, somewhat deciduous; lateral line in the centre of body with 53-58 scales; pre-dorsal scale count 27-29; lateral transverse scales 11-12/10-12.

Colour: Body colour silvery with black dots on the body above lateral line on dorsal side; a blotch over the nape and near origin of dorsal fin; fins pale in appearance; body shiny and transparent in living condition.

Location: Panchkula (Nada Sahib), Yamunanagar, Ambala, Karnal.

Genus: *Puntius* Hamilton-Buchanan
1822, *Puntius*, Hamilton-Buchanan. *Fish Ganges*, pp. 310, 388.

Body stout, deep and compressed; head short, snout obtuse; mouth arched, terminal or slightly inferior without inner folds, not protrusible; lips thin without horny coverings and tubercles; eyes moderate, dorsolateral in position; pharyngeal teeth in three rows; barbels 4, 2 or none; dorsal fin short, commences almost opposite base of pelvic fins, last undivided dorsal ray either ossified and serrated; anal fin short with a rays; caudal fin deeply emarginated or forked; scales moderate, cycloid; lateral line complete or incomplete with 22-45 scales in longitudinal series.

Keys to Species

(i) Barbels present. .....(ii)

Barbels absent. .....(v)

(ii) Two pairs of barbels. .....(iv)

One pairs of barbels. .....(iii)

(iii) Dorsal fin inserted equidistant from snout tip to caudal fin base; lateral line with 27-28 scales; last unbranched dorsal fin ray osseous and entire; a black blotch on 21-23 scales on caudal peduncle; another dark spot on or behind the operculum; dorsal fin also have dark blotch at their base. .....***Puntius chola***

Dorsal fin inserted near to snout-tip than to caudal fin base. ..... (iv)

(iv) Last unbranched dorsal ray osseous and serrated; a faint blotch at caudal fin base. .....***Puntius sarana***

Lateral line with less then 26 scales. .....(v)

(v) One black spot on the body near caudal fin base; dorsal spine weak; upper jaw slightly projecting. ..... ***Puntius sophore***

Two black spots on the body. .....(vi)

(vi) Dorsal hard fin-ray serrated in its posterior edge; lateral line scales 23-25; a dark blotch above anal fin and similar faint spot behind operclum or above pectoral fin. .....***Puntius ticto***

Dorsal spine smooth; lateral line with 22-23 scales in longitudinal series; a black blotch over anal fin running back towards caudal fin base in the form of dark band at their base. .....***Puntius terio***

***(a) Puntius chola* (Hamilton-Buchanan) (Fig. 35)**

Syns. 1822, *Cyprinus chola*, Hamilton-Buchanan. *Fish Ganges*, pp. 312, 389.

1878, *Barbus chola*, Day. *Fish. India*, p. 571, pl. 142, fig. 4.

1940, *Barbus titius*, Hora and Gupta. *J. Roy. Asiat. Soc. Beng.* (Sci.), **6**(2): 82.

1991, *Puntius chola*, Talwar and Jhingran. *Inland Fishes*, **1**: 264, fig. 90.

1999, *Puntius chola*, Jayaram. *The Freshwater Fishes of The Indian Region*, p. 111.

Fin formula: $D._{iii\ 8'}$ $A._{ii-iii\ 5'}$ $P._{i\ 14-15'}$ $V._{i\ 8}$

Common Name: Thiker, Chidhu, Putthi.

External Characters: Body stout, deep (depth being 2.6 times in standard length) and compressed

laterally; dorsal side more convex; head short, its length being 3.3 times in standard length; mouth moderate and oblique; dorsal profile slightly concave over the nape; barbels short maxillary pair only; dorsal fin inserted in the middle of the body (standard length), having a smooth unbranched osseous ray; pectorals and pelvics are of equal length; pectoral, pelvic and anal fin equidistant from each other; caudal fin deeply emarginate; scales moderate; lateral line complete with 27-28 scales; pre-dorsal scales 9-10; lateral transverse scales count 6/5.

Colour: Body uniform silvery with a slight greenish tinge on dorsal side; a large orange-red blotch on operculum and often a small black spot behind the operculum; a large black spot on the 21-23 lateral line scales present at the base of caudal; a longitudinal dark band often seen at the base of anterior dorsal fin ray also (in fresh specimens); eyes orange-yellow in appearance; fins delicate yellowish-white in colour.

Location: Panchkula(Nada Sahib),Yamunanagar, Ambala, Karnal, Fatehabad, Sirsa.

(b) *Puntius sarana sarana* (Hamilton-Buchanan) (Fig. 36)

Syns. 1822, *Cyprinus sarana*, Hamilton-Buchanan. *Fish Ganges*, pp. 307, 388.

1878, *Barbus sarana*, Day. *Fish. India*, p. 560, pl. 136, fig. 2.

1959, *Puntius sarana*, Misra. *Rec. Indian Mus.*, **57**: 155.

1991, *Puntius sarana sarana*, Talwar and Jhingran. *Inland Fishes*, **1**: 283, fig. 96.

1999, *Puntius sarana sarana*, Jayaram. *The Freshwater Fishes of The Indian Region*, p. 113, pl. 5, fig. 2.

Fin formula: D. $_{iii/8}$ A. $_{iii/5}$ P. $_{i/15}$ V. $_{i/8}$

Common Name: Bhangan, Kharmi, Kunhe, Puthia, Pothi.

External Characters: Body oblong, deep, its depth being 2.9 times in standard length; dorsal profile more convex than ventral; head oval, blunt and moderate (being 3.8-4.0 times in standard length); eyes moderate, being 4.5 times in head length; mouth terminal; lips equal in size; two pair of barbels (maxillary and rostral) present, rostrals being shorter than eye diameter, maxillary pair quite large; dorsal fin equidistant from snout tip and caudal fin base; caudal fin forked; dorsal fin last unbranched ray osseous and posteriorly serrated; scales medium sized; lateral line almost complete with 31-32 scales; pre-dorsal scales 11-12; lateral transverse scale count 6/4.

Colour: Body silvery with olive-green dorsal surface; upper portion of scales with green edges; cheeks golden; fins pale in colour; barbels reddish-brown in fresh specimens.

Location: Yamunanagar, Ambala, Karnal.

(a) *Puntius sophore* (Hamilton-Buchanan) (Fig. 37)

Syns. 1822, *Cyprinus sophore*, Hamilton-Buchanan. *Fish Ganges*, pp. 310, 389.

1878, *Barbus sophore*, Day. *Fish. India*, p. 566, pl. 143, fig. 4.

1959, *Puntius sophore*, Misra. *Rec. Indian Mus.*, **57**: 155.

1991, *Puntius sophore*, Talwar and Jhingran. *Inland Fishes*, **1**: 289, fig. 99.

1999, *Puntius sophore*, Jayaram. *The Freshwater Fishes of The Indian Region*, p. 114, pl. 4, fig. 1.

Fin formula: D. $_{iii/8\text{-}9}$ A. $_{iii/5}$ P. $_{i/15}$ V. $_{i/8}$

Common Name: Pothi, Thiker, Chidhu.

External Characters: Body stout, deep having more convex dorsal profile; its depth being 2.8-3.0 time in standard length; head short; snout have well marked depression; mouth terminal; barbels absent; dorsal fin inserted more towards snout tip than to caudal fin base, its last unbranched hard ray smooth and osseous; caudal fin deeply emarginated or forked; scales moderate sized; lateral line complete with 25-26 scales; pre-dorsal scales 9; lateral transverse scales 5/3-4.

Colour: Body colour shiny silvery; dorsal side greyish-black; lateral side having shiny bluish lustre in fresh condition; a black blotch at the base of dorsal fin (3rd-5th ray) or adjacent to it; similar deep black blotch at the caudal fin base on 22nd-24th scales; anal and pelvic fins have orangish tinge during breeding season; operculum golden-yellow; some specimens have faint orange-reddish band run along the flank or lateral sides especially seen in the fresh specimens.

Location: Panchkula (Nada Sahib), Yamunanagar, Ambala, Karnal, Hisar, Sirsa.

(d) *Puntius terio* (Hamilton-Buchanan) (Fig. 38)

Syns. 1822, *Cyprinus terio*, Hamilton-Buchanan. *Fish Ganges*, pp. 313, 389.

1878, *Barbus terio*, Day. *Fish. India*, p. 580, pl. 144, fig. 3.

1967, *Barbus terio*, Sterba. *Freshwater Fishes of the World*, p. 299, fig. 365.

1991, *Puntius terio*, Talwar and Jhingran. *Inland Fishes*, **1**: 290, fig. 100.

1999, *Puntius terio*, Jayaram. *The Freshwater Fishes of The Indian Region*, p. 114.

Fin formula: D. $_{iii/8}$ A. $_{ii/5}$ P. $_{i/14}$ V. $_{i/8}$

Common Name: Teri-putthi, One-spot barb.

External Characters: Body stout, deep and compressed, its depth being 2.4-2.5 times in standard length; head narrow, conical, being 3.4 times in standard length; eyes moderate being 3 times in head length; mouth terminal; barbels absent; dorsal fin more towards caudal fin base than to snout-tip, its last unbranched ray osseous and smooth; pectorals and pelvics are of same length; caudal fin forked; scales medium sized; lateral line incomplete with 22-23 scales in longitudinal series; pre-dorsal scales 8-9, lateral transverse scales count 5/5.

Colour: Body colour silvery with more greenish grey on dorsal side and becomes light as we move towards lateral line; a dark black rounded-blotch on the 16th-18th lateral line scales above anal fin which runs backward to caudal fin base in the form of fine streak; fins hyaline, delicate and pale in colour; dorsal fin have dark spots.

Location: Panchkula (Nada Sahib), Yamunanagar Ambala.

(e) *Puntius ticto* (Hamilton-Buchanan) (Fig. 39)

Syns. 1822, *Cyprinus ticto*, Hamilton-Buchanan. *Fish Ganges*, pp. 314, 398, pl. 8, fig. 87.

1878, *Barbus ticto*, Day. *Fish. India*, p. 576, pl. 144, fig. 7.

1938, *Barbus ticto*, Hora and Misra. *J. Bombay Nat. Hist. Soc.*, **40**(1): 28, fig. 3.

1959, *Puntius ticto*, Misra. *Rec. Indian Mus.*, **57**: 156.

1991, *Puntius ticto*, Talwar and Jhingran. *Inland Fishes*, **1**: 291, fig. 101.

1999, *Puntius ticto*, Jayaram. *The Freshwater Fishes of The Indian Region*, p. 114, pl. 4, fig. 2.

Fin formula: D. $_{iii/8}$ A. $_{ii-iii/5}$ P. $_{i/12-14}$ V. $_{i/8}$

Common Name: Thiker, Putthi, Two-spot barb.

External Characters: Body elongate, laterally compressed with a depth of 2.6 times in standard length; head short, conical and narrow, its length being 3.4-3.7 times in standard length; mouth small and descends obliquely, terminal; barbels absent; dorsal fin inserted almost in the middle of the body or slightly more towards snout-tip, but arises always posterior to pelvic fin origin; its last unbranched ray strong, osseous and posteriorly serrated; length of pectoral and pelvic fins almost same; pelvic fin equidistant from pectoral and anal fin; caudal fin forked; scales medium sized; lateral line ceases after 6th-8th scale and hence incomplete with 23-25 scales in incomplete series; pre-dorsal scales 9-10; lateral transverse scales 5/4.

Colour: Body brilliant silvery shine with greyish-green dorsal side, silvery white ventral; operculum has golden tinge in fresh condition; a black spot on 4th lateral line scale above pectoral fin; similar but large and golden-edged blotch present on the 17th-18th scales lateral series at the end of anal fin on caudal peduncle; fins dark; dorsal fin have thin transverse bands.

Location: Yamunanagar, Ambala, Karnal, Panchkula, Fatehabad, Hisar, Sirsa.

Genus: *Tor* Grey

1834, *Tor*, Grey. *Illustrations of Indian Zoology*, **2**: 196.

Body elongated, moderately compressed with rounded abdomen; head moderate with prominent pointed snout studded with tubercles; mouth sub-inferior; upper jaw protractile; lower lip thick, fleshy, continuous at the corners; barbels 4 (rostral and maxillary pair); pharyngeal teeth in 3 rows; dorsal fin mostly inserted opposite to pelvic fin, with 9 branched rays and a smooth spine; anal fin with 5 branched rays; caudal fin deeply forked; scales large sized with parallel stirae; lateral line complete.

***Tor putitora* (Hamilton-Buchanan) (Fig. 40)**

Syns. 1822, *Cyprinus putitora*, Hamilton-Buchanan. *Fish Ganges*, pp. 303, 388.

1878, *Barbus tor*, Day. *Fish. India*, p. 564, pl. 136, fig. 5.

1939, *Barbus* (*Tor*) *putitora*, Hora. *J. Bombay Nat. Hist. Soc.*, **41**(2): 277.

1982, *Tor putitora*, Tilak and Sharma. *Fishes of India and Angling*, p. 39, figs. 4, 5 and 6.

1991, *Tor putitora*, Talwar and Jhingran. *Inland Fishes*, **1**: 308, fig. 109.

1999, *Tor putitora*, Jayaram. *The Freshwater Fishes of The Indian Region*, p. 96, pl. 2, fig. 2.

Fin formula: D. $_{iv/8-9}$ A. $_{ii/5}$ P. $_{i/16-17}$ V. $_{i/8}$

Common Name: Mahasir, Mahsheer.

External Characters: Body elongated, streamlined, and compressed with rounded abdomen, its depth being 4.1 times in standard length; head conical or pointed, its length considerably greater than maximum body depth and 3.6 times in standard length; eyes moderate not visible underneath the head; mouth moderate; lips thick and fleshy, continuous at the corners of mouth; two pairs of barbels present of more or less equal length or rostrals slightly shorter than maxillary pair; generally larger than eye diameter; scales large and heavy; dorsal fin inserted midway or slightly nearer to snout tip than to caudal fin base; pelvic fins equidistant from pectorals and anal fin; caudal fin forked; lateral line complete with 28 scales; pre-dorsal scales 8; lateral transverse scales 4/2-3.

Colour: Body colour varies according to the habitat and water inhabited by the fish; body colour generally silvery with greenish-grey dorsal side; flank light-orange in appearance which fades on the ventral side and becomes silvery white; head slightly yellowish on lower side; lateral line scales greenish in colour with orangish tinge; pectoral, pelvic and anal fins light yellow; dorsal fin patchy reddish-green in colour in fresh condition and have greenish-grey anterior border.

Location: Yamunanagar, Panchkula (Nada Sahib).

DESCRIPTION OF THE GENERA OF ORDER BELONIFORMES

Superorder : Acanthopterigii

Series : Atherinomorpha

Order : Beloniformes

Suborder : Belonoidei

Family : Belonidae

Genus: *Xenentodon* Regan

1911, *Xenentodon*, Regan. *Ann. Mag. Cat. Hist.*, (8) **7**: 332.

Body long cylindrical with point head and snout; mouth terminal with wide cleft reaching upto eye-orbit; eyes moderate, superior, not visible from underneath the head, jaws produced forward to form pointed beaks with narrow sharp, alternating conical and canine teeth; deep longitudinal groove along upper surface of head; barbels absent; gill rakers absent; dorsal fin nearly opposite to anal fin with no spines; caudal fin truncated; scales very small, cycloid; lateral line running more towards ventral side, complete.

***Xenentodon cancila* (Hamilton-Buchanan) (Fig. 41)**

Syns. 1822, *Esox* (*Belone*) *cancila*, Hamilton-Buchanan. *Fish Ganges*, pp. 213, 380, pl. 27, fig. 70.

1877, *Belone cancila*, Day. *Fish. India*, p. 511, pl. 118 fig. 5.

1959, *Xenentodon cancila*, Misra. *Rec. India Mus.*, **57**: 198.

1991, *Xenentodon cancila*, Talwar and Jhingran. *Inland Fishes*, **2**: 743.

1999, *Xenentodon cancila*, Jayaram. *The Freshwater Fishes of The Indian Region*, p. 336, fig. 176.

Fin formula: D. $_{17}$ A. $_{17-18}$ P. $_{11}$ V. $_{6}$

Common Name: Takla or Kawwa machhi, Freshwater garfish.

External Characters: Body gently elongated and sub-cylindrical, its depth being 11.9-12.1 times in standard length; a deep longitudinal groove on the upper surface of head; eyes large and situated on the upper part of head (not visible from below); inter-orbital region straight; mouth prolonged into beak; barbels absent; dorsal fin inserted almost opposite to anal fin; caudal fin truncated; pectoral fin wing-like; lateral line complete and descends more towards ventral side; scales extremely small, cannot be

counted easily.

Colour: Body appears greenish-grey on dorsal side with whitish-yellow or silvery-green ventral surface; a silvery-brown band on the lateral and dorsal side of the body (which becomes dark brown in preserved condition); dorsal fin dark edged; an inverted V-shaped groove on head (clearly visible in the preserved specimens).

Location: Yamunanagar (Dadupur Headworks).

DESCRIPTION OF THE GENERA OF ORDER CYPRINODONTIFORMES

Superorder : Acanthopterigii
Series : Atherinomorpha
Order : Cyprinodontiformes
Family : Poecilidae
Subfamily : Poecilinae

Genus: *Gambusia* Poey

1854, *Gambusia*, Poey. *Memorias sobra la historia natural de la isla de cuba*, **1**: 382, 390.

Body short, somewhat cylindrical; anteriorly compressed; abdomen rounded; head short; snout pointed with oblique mouth; cleft not reaching to the eye-orbit; eyes quite large as compared to head length, visible from underside the head; lips thin; lower jaw slightly projecting; teeth on jaws, dorsal fin inserted behind anal fin origin and without spines; barbels absent; anal fin simple in female and having an anal process in males which is longer than head; caudal fin rounded; scales medium-sized; lateral line complete.

Gambusia affinis (Baird and Girard) (Fig. 42)

Syns. 1853, *Heterandria affinis*, Baird and Girard. *Proc. Acad. Nat. Sci. Philad.*, **6**: 390.

1962, *Gambusia affinis patruelis*, Misra. *Rec. Indian Mus.*, **57**: 207, fig. 124.

1968, *Gambusia affinis holbrooki*, Das and Rampal. *Kmr. Sci.*, **5**(1/2): 36.

1991, *Gambusia affinis*, Talwar and Jhingran. *Inland Fishes*, **2**: 756, fig. 242.

1999, *Gambusia affinis*, Jayaram. *The Freshwater Fishes of The Indian Region*, p. 345, fig. 181.

Fin formula: D. $_{ii/6-7}$ A. $_{iii/17}$ P. $_{iii/10}$ V. $_{i/5}$

Common Name: Mosquito fish.

External Characters: Body slightly elongated as compared to width (its depth being 3.3-3.4 times in standard length); head moderate being 4.0-4.4 times in standard length; snout pointed with projected under lip; eyes quite large, its diameter being 3 times in head length; barbels absent; ventral side had awkward bulge upto anal fin origin; dorsal fin inserted behind anal fin origin in the 2nd half of body having 8-9 rays; anal fin in males with long anal process called **Gonopodium** as long as head; scales fairly large to medium in size; lateral line with 33-34 scales; pre-dorsal scales 15-17; lateral transverse scales count $4^{1/2}/5^{1/2}$.

Colour: Body colour translucent silvery with bluish appearance; dorsal side greyish spotted; fins yellowish; dorsal and caudal fin spotted black; gravid females have a large black patch on the anal region of abdominal as the marks of identification.

Location: Found at Fish Farms in Haryana.

DESCRIPTION OF THE GENERA OF ORDER SYNBRANCHIFORMES

Superorder : Acanthopterigii
Series : Percomorpha
Order : Synbranchiformes
Suborder : Mastacembeloidei
Family : Mastacembelidae
Subfamily : Mastacembelinae

Genus: *Mastacembelus* Scopoli

1777, *Mastacembelus*, Scopoli. *Introd. Hist. Nat.*, p. 458.

Body eel-like, elongated and laterally compressed with depressed and pointed snout; rostrum simple and toothless; anterior nostrils have flaps; eyes small superior; lips thin; jaws unequal with minute teeth; pre-orbital spine may be present; barbels absent; dorsal fin have 33-38 depressible spines and started above pectoral fin origin; caudal fin rounded; anal fin with 3 spines; scales very minute, cycloid; lateral line present.

Mastacembelus armatus (Lecepede) (Fig. 43)

Syns. 1800, *Macrognathus armatus*, Lacepede. *Hist. Nat. Poiss.*, **2**: 286.

1876, *Mastacembelus armatus*, Day. *Fish.*

India, p. 340, pl. 73, fig. 3.

1955, *Mastacembelus armatus*, Munro. *Marine and Freshwater Fishes of Ceylon*, p. 267.

1959, *Mastacembelus armatus*, Misra. *Rec. Indian Mus.*, **57**: 313.

1991, *Mastacembelus armatus*, Talwar and Jhingran. *Inland Fishes*, **2**: 1031.

1999, *Mastacembelus armatus*, Jayaram. *The Freshwater Fishes of The Indian Region*, p. 358, fig. 188.

Fin formula: $D_{I/XXXIII-XXXVIII}\ D_2+C+A_{III/155-170}\ P_{21-23}\ V_0$

Common Name: Bahm, Bam, Freshwater spiny eel.

External Characters: Body slender, long with pointed head and projecting toothless snout (rostrum), its depth being 11-13 times in standard length; small pores on snout; eyes small, subcutaneous; inter-orbital space nearly flat; pre-operculum armed with 3-4 denticulations at its angle; pre-orbital spine present under skin; mouth small; jaws with cartilaginous covering teeth; barbels absent; spinous dorsal fin originated above pectoral fins; dorsal, anal and caudal fin continuous with each other (not distinctively separated); pelvic or ventral fins absent; lateral line complete; scales minute hence cannot be counted.

Colour: Body colour greyish-green on the dorsal side to progressively lighter ventral surface; soft dorsal and anal fin bases have row of dark spots or bands; a dark band passes through eyes acquiring a zig-zag path in posterior half of the body extending upto caudal fin base; an oblong bar shaped spots also present below the region of dorsal spines.

Location: Yamunanagar, Panchkula (Nada Sahib), Ambala, Karnal, Panipat.

DESCRIPTION OF THE GENERA OF ORDER PERCIFORMES

Superorder: Acanthopterigii
Series : Percomorpha
Order : Perciformes
Suborder : Percoidei
Family : Chandidae (=Ambassidae)

Genus: *Chanda* (Hamilton-Buchanan)
1822, *Chanda*, Hamilton-Buchanan. *Fish. Ganges*, pp. 103, 370.

Body stout, deep and laterally compressed and quite transparent; head short and upturned; snout sharp; mouth large and wide, its cleft reaches upto eye-orbit; lips thin; lower jaw conspicously projecting; eyes large, superior, with serrated (23 denticles) anterior margins; supraorbital ridge smooth, ending into indistinct spine; jaws having villiform teeth, canines generally present; barbels absent; lower limb of pre-oprerculum serrated or spinous; dorsal fin two types- 1st being spinous and 2nd having one spine and other simple rays seperated by a distinct visible notch; anal fin with 3 spines caudal fin forked; lateral line complete but indistinct because of minute cycloid scales. Inhabits both fresh (running and standing) and brackish water.

Chanda nama (Hamilton-Buchanan) (Fig. 44)

Syns. 1822, *Chanda nama*, Hamilton-Buchanan. *Fish. Ganges*, pp. 109, 371, pl. 39, fig. 37.

1875, *Ambassis nama*, Day. *Fish. India*, p. 50, pl. 14, fig. 5.

1959, *Ambassis nama*, Misra. *Rec. Indian Mus.*, **57**: 223.

1991, *Chanda nama*, Talwar and Jhingran, *Inland Fishes*, **2**: 799, fig. 249.

1999, *Chanda nama*, Jayaram. *The Freshwater Fishes of The Indian Region*, p. 369, fig. 193.

Fin formula: $D_{I/VII}+D_{2\,I\,16}\ A_{III/17}\ P_{11-13}\ V_{I/5}$

Common Name: Sheesha machhi, Makhni, Glass-perchlet.

External Characters: Body fairly deep (its depth being 2.8-3.1 times in standard length) and laterally compressed sharply; dorsal and ventral profile equally convex; a considerable rise from nape upto dorsal fin origin; head small, its length being equal to maximum body depth; mouth large, terminal, with prominent lower jaw produced forward giving rise to upturned mouth; 2-3 canine teeth are present on lower jaw; fine teeth on vomer and palatine; maxilla reaches upto 1/3rd of the eye-orbit; barbels absent; dorsal fin in two halves, first half with 7 spiny rays and second half with 1 spiny and 16 soft rays; pelvic fins 2/3rd of pectorals and do not reach anal fin; anal and dorsal fin are of almost same width; caudal fin forked; scales minute, irregularly arranged and partly deciduous; lateral line indistinct but complete with 98-107 scales

in lateral series; scales generally absent below and infront of dorsal fin (above lateral line) and on cheeks.

Colour: Body colour generally transparent silvery-yellow in fresh condition, becomes yellowish-white in preserved condition; a silvery band along the flank, minute black dots scattered all over the body; a dark black spot or patch on shoulder present; upper portion of 1st dorsal spiny fin rays black-edged.

Location: Yamunanagar (Dadupur Headworks), Panchkula, Ambala, Karnal, Sirsa.

Genus: *Parambassis* Bleeker

1874, *Parambassis*, Bleeker. *Nat. Verh. Holland. Maatsch. Wetensch.*, **2**(2): 86, 102.

Body elongated and highly compressed laterally; head short; snout pointed; mouth moderate to large with oblique gape; cleft extending to anterior margin of eyes; supraorbital ridge ending posteriorly into one or two spines; pre-orbital serrated with 6-7 denticulations at anterior margins and some serrations on suborbital and posterior margins also; villiform teeth on the jaws; tongue without teeth; barbels absent; pre-opercular vertical margins smooth; scales small sized; lateral line complete; dorsal fin in two parts (spinous + soft rays), caudal fin deeply forked; cheeks also have scales. Inhabits fresh and brackish water both.

***Parambassis ranga* (Hamilton-Buchanan) (Fig. 45)**

Syns. 1822, *Chanda ranga*, Hamilton-Buchanan. *Fish. Ganges*, pp. 113, 371, pl. 16, fig. 38.

1875, *Ambassis ranga*, Day. *Fish. India*, p. 51, pl. 14, fig. 6.

1959, *Ambassis ranga*, Misra. *Rec. Indian Mus.*, **57**: 224.

1991, *Pseudambassis ranga*, Talwar and Jhingran, *Inland Fishes*, **2**: 805.

1999, *Parambassis ranga*, Jayaram. *The Freshwater Fishes of The Indian Region*, p. 370, fig. 194.

Fin formula: $D._{1/VII} + D._{2\ I\ 12}$ $A._{III/15}$ $P._{I/9}$ $V._{I/5}$

Common Name: Chitti-kangi, Sheesha machhi, Glassy-fish.

External Characters: Body stout, fairly deep (its depth being 2.1 times in standard length), laterally compressed with dorsal and ventral profile equally convex, slightly concave over the eyes; head short its length being 2.5-3.0 times in standard length of fish; maxilla reaches below middle of eye orbit; eyes large; pre-opercle entire with double serrated margin at angles; mouth oblique, terminal with slightly projecting lower jaw; pre-orbital studded with serrations or denticulations on anterior as well as posterior margins; teeth arranged villiform on jaws, vomer and palate; canine teeth absent on lower jaw; barbels absent; fins hyaline and straight; caudal fin deeply forked; caudal peduncle quite narrow; dorsal fin divided in two parts (spinous and soft rays); width of dorsal and anal fin more or less same; scales very small, partly deciduous; lateral line complete but slightly indistinct with 85-90 scales (approx.); lateral line curves upward near the shoulder (towards dorsal fin base) and then becomes straight from anal fin origin upto caudal fin base; cheeks also having rows of scales.

Colour: Body quite transparent with olive tinge; a dark blotch on the shoulder (behind operculum); some silvery lateral stripes on the flank; margins of dorsal, anal and caudal fins usually dark edged.

Location: Hisar.

Superorder : Acanthopterigii

Series : Percomorpha

Order : Perciformes

Suborder : Labroidei

Family : Cichilidae

Genus: *Oreochromis* Gunther

1889, *Oreochromis*, Gunther. *Ann. Mag. Nat. Hist.*, (6) **4**: 70.

Body stout, deep, laterally compressed; dorsal profile slightly more convex than ventral; mouth large, terminal; head compressed with slightly concave over eyes; teeth in 3-5 rows on jaws; palatine teeth absent; maxilla reaching upto anterior margin of eyes in many cases but ends before it in others; barbels absent; dorsal fin inserted above pectoral fin base and reaches upto end of anal fin; caudal fin truncated; scales moderate, cycloid; lateral line present which breakup after17-18 scales and hence incomplete.

***Oreochromis mossambica* (Peters) (Fig. 46)**

Syns. 1852, *Chromis* (*Tilapia*) *mossambicus*, Peters. *Montab. Akad. Wiss., Berlin*, p. 681.

1952, *Tilapia mossambica*, Jones and Sarojini. *J. Bombay Nat. Hist. Soc.*, **50**(3): 606.

1983, *Oreochromis mossambica*, Trewavas. *Tilapiine Fishes*, p. 292, fig. 100.

1991, *Oreochromis mossambica*, Talwar and Jhingran, *Inland Fishes*, **2**: 887.

1999, *Oreochromis mossambica*, Jayaram. *The Freshwater Fishes of The Indian Region*, p. 400, fig. 213.

Fin formula: $D._{XVI/13}$ $A._{III/10-11}$ $P._{13-14}$ $V._{I/5}$

Common Name: Tilapia.

External Characters: Body stout, fairly deep (depth being 2.5-2.8 time in standard length) and laterally compressed; dorsal profile convex than ventral; head short, compressed but slightly concave over the eyes; head length 2.7-2.8 times in standard length; head depth 3/4th of head length; mouth cleft reaching upto eye orbit or ending before it; teeth on jaws, absent on palate; barbels absent; dorsal fin originates above the pectoral fin base, its longest soft ray usually extending upto caudal fin base; anal fin with 3 spines, its length being almost twice of its height, its longest soft ray also extends to caudal fin base; ventral fin with one spine and a typically long soft ray; caudal fin truncated with rounded corners; scales moderate, cycloid; lateral line present which breaks up after 17-18 scales hence in two rows (upper row of 18-21 scales while lower row of 16-18 scales); pre-dorsal scales 8-9; lateral transverse scale count 5/13-14 (from upper lateral line).

Colour: Body silvery with colourful bands on flank and fins; a dark blotch on or behind operculum; 10-11 lateral bands (in oblique fashion) present on both side of body; caudal fin also has 6-7 vertical bands along with similar lateral bands on dorsal, anal and ventral fins; scales have dark edges; pectoral fin have reddish tinge; caudal fin also have red margins.

Location: Yamunanagar, Ambala, Karnal, Sirsa, Hisar.

Order : Perciformes
Suborder : Goboidei
Family : Gobiidae
Subfamily : Gobiinae

Genus: *Glossogobius* Gill

1862, *Glossogobius*, Gill. *Ann. Lye. Nat. Hist. New York*, **7**: 46.

Body elongated, sub-cylindrical; head depressed; snout elongate and rounded; eyes superior, immediate of head and together; head scales behind started behind eyes, absent on cheeks and operculum; mouth terminal and oblique, slightly upturned due to prominent lower jaw; lips thick; villiform teeth on jaws, arranged in several rows; canines absent or rudimentary; gill-openings of moderate width; tongue bilobed; barbels absent; dorsal fin in 2 sets, seperated from each other; ventral fins united to form disc; caudal fin oblong, pointed or rounded; scales moderate, cycloid; lateral line absent.

***Glossogobius giuris giuris* (Hamilton-Buchanan) (Fig. 47)**

Syns. 1822, *Gobius giuris*, Hamilton-Buchanan. *Fish. Ganges*, p. 51.

1876, *Gobius giuris*, Day. *Fish. India*, p. 294, pl. 67, fig. 1.

1959, *Glossogobius giuris*, Munro. *Marine and Freshwater Fishes of Ceylon*, p. 239.

1991, *Glossogobius giuris*, Talwar and Jhingran, *Inland Fishes*, **2**: 274.

1999, *Glossogobius giuris giuris*, Jayaram. *The Freshwater Fishes of The Indian Region*, p. 414, pl. 16, fig. 3.

Fin formula: $D._{I/VI}$ + $D._{I\,9-10}$ $A._{I/9}$ $P._{18-19}$

Common Name: Gobi, Nahi.

External Characters: Body elongated, sub-cylindrical anteriorly, its depth being 5.6 times in standard length; abdomen rounded; head dorso-ventrally depressed, its length being 3.2-3.5 times in standard length; eyes placed closed to each other on dorsal side, superior, subcutaneous, small in size; mouth oblique upward; cleft of mouth extends below anterior margin of eyes; lower jaw more prominent and both jaws armed with several rows of teeth, outer row having large curved teeth; tongue bilobed gill-openings continued beyond eyes on anterior part of head; barbels absent; dorsal fin in two sets (seperated by short interspace), 1st dorsal set of spinous rays; 2nd dorsal fin as well as anal fin have one spine and rest soft rays; pectoral fins pointed; ventral fins joined to form a disc below; caudal fin oblong or pointed;

scales of moderate size and ctenoid; lateral line incomplete; 28-30 scales in lateral series; pre-dorsal scales 13-15.

Colour: Body generally yellow-silvery with 5-6 dark, big, rhomboidal blotches on the flank; dorsal, anal and caudle fins studded with dark spots.

Location: Yamunanagar, Ambala, Karnal, Panipat, Sirsa, Hisar, Panchkula.

Order : Perciformes

Suborder : Anabantoidei

Family : Anabantidae

Genus: *Anabas* Cuvier

1816, *Anabas*, Cuvier. *Le Regne Animal*, **2**: 339.

Body oblong and compressed laterally with anterior part of body broader as compared to posterior part; head moderate with snout slightly depressed; mouth terminal, oblique, cleft not reaching upto eyes; eyes large jaws equal with villiform vomerine teeth; dorsal fin two types of rays (spinous+soft), united; anal fin also of same structure but short in size; caudal fin rounded; scales moderate in size, ctenoid; lateral line interrupted; an accessory breathing apparatus present on the cavity of first branchial arch.

***Anabas testudineus* (Bloch) (Fig. 48)**

Syns. 1795, *Anathias testudineus*, Blotch. *Naturges. Austland. Fishes*, (6) p. 121, pl. 322.

1876, *Anabas scandens*, Day. *Fish. India*, p. 370, pl. 78, fig. 3.

1964, *Anabas testudineus*, Das. *Icthyologia*, **3**(1/2): 93.

1991, *Anabas testudineus*, Talwar and Jhingran, *Inland Fishes*, **2**: 996, fig. 283.

1999, *Anabas testudineus*, Jayaram. *The Freshwater Fishes of The Indian Region*, p. 434, fig. 224.

Fin formula: D. $_{XVII/8-9}$ A. $_{X/10}$ P. $_{I/15}$ V. $_{I/5}$

Common Name: Koi, Kabai, Climbing perch.

External Characters: Body elongated, slightly deep with dorsal and ventral profile almost equally convex; its depth being 3 times in standard length; head moderate, its length being 2.7 times in standard length; snout rounded and covered by scales; mouth terminal, slightly oblique; villiform teeth on vomer; barbels absent; dorsal fin started above pectoral fin and having 16 spinous and 8-9 soft rays; anal fin starts from the posterior end of pectorals, having 10 spiny and 10 soft rays; operculum very serrated (with two distinctly visible spines); caudal peduncle very short; pectoral and caudal fin rounded; scales moderate, ctenoid; lateral line scales 26, interrupted, splits after 15th scale; pre-dorsal scales 7-8; lateral transverse scales 4/9 (with respect to upper lateral line).

Colour: Body olive-green to dark grey in colour all over the body (lighter on ventral side in fresh specimens); a blotch at the base of caudal fin base (fades in preserved specimen); a similar black spot on the upper side at the base of pectoral fin or below the operculum dorsal and caudal fin dark greyish; pectoral and pelvic fin yellowish-grey; pelvic fin pale-orange in fresh condition.

Location: Yamunanagar.

Order : Perciformes

Suborder : Anabantoidei

Family : Belontidae

Subfamily : Trichogasterinae

Genus: *Colisa* Cuvier

1831, *Colisa*, Cuvier. *Hist. Nat. Poiss.*, **7**: 359.

Body oblong, laterally compressed; head moderate with blunt snout; mouth slightly upturned, but terminal and protrusible; cleft not reaching below orbit; villiform small teeth on jaws only; eyes large, laterally placed; operculum smooth edged, preoperculum usually serrated on its ventral edges; a suprabranchial organ as accessory breathing apparatus also present; single dorsal fin present starting above pectoral fin base, spinous portion more developed than soft; ventral fins in the form of single filiform ray; caudal fin slightly emarginated or truncated with rounded tips; scales moderate to large, ctenoid in structure; lateral line interrupted; barbels absent.

***Colisa fasciatus* (Schneider) (Fig. 49)**

Syns. 1801, *Trichogaster fasciatus*, Schneider. *Syst. Icth.*, p. 164, pl. 36.

1876, *Trichogaster fasciatus*, Day. *Fish. India*, p. 374, pl. 76, fig. 6.

1991, *Colisa fasciatus*, Talwar and Jhingran, *Inland Fishes*, **2**: 1002.

1999, *Colisa fasciatus*, Jayaram. *The Freshwater Fishes of The Indian Region*, p. 442, fig. 228.

Fin formula: D. $_{XVI/10}$ A. $_{XV/15}$ P. $_{10}$ V. $_{i}$

Common Name: Kungee, Kangi.

External Characters: Body oval or oblong, laterally compressed, its depth being 2.2-2.3 times in standard length; head small, its length being 2.8-3.1 times in standard length; mouth small, obliquely placed (directed upward) with protrusible lips studded with tubercles; preopercles and subopercles serrated; palate smooth or edentate, small conical teeth on jaws; dorsal and anal fins are more or less of same length and same width, and composed of both spinous and soft rays; pectoral fin spatulate; pelvic fin filiform and quite long reaching upto or beyond the base of caudal fin; caudal fin slightly notched inside or truncated with rounded corners; scales moderate in size and ctenoid; lateral line with 28-29 scales, interrupted at 2 places after 13th and 16th scale (making the lateral line in 3 horizontal rows of 1-13, 14-16 and 17-29 scales); pre-dorsal scales count 16-18; lateral transverse scales 5/7-8 (with respect to upper lateral line).

Colour: Dorsal side of body dull greenish-grey with orangish-blue hands descends downwards obliquely along the flank (from dorsal to ventral side); some blue coloured in complete bands also present between the complete ones; fins variegated with black or the dorsal and ventral fin along with caudal have alternative dark and pale spots and bars; dorsal spine slightly orangish in fresh specimens.

Location: Panchkula, Yamunanagar, Ambala.

Order : Perciformes

Suborder : Chanoidei

Family : Channidae

Genus: *Channa* Scopoli

1777, *Channa*, Scopoli. *Introd. Hist. Nat.*, p. 459.

Body elongated, cylindrical but slightly compressed behind middle of anal fin; head large, having scales and cephalic pits on snout; mouth fairly large, cleft extends to below eye-orbit; eyes lateral in position; teeth present on jaws, vomer and palate; anterior nostrils tubular; gill openings wide; dorsal and anal fin long and spineless; pelvic fin small and sub-abdominal; an accessory respiratory organ present in cavity of gill chamber formed of thin bony laminae; caudal fin rounded; scales moderate sized, cycloid or ctenoid; scales on head larger than body scales, plate-like and arranged in the form of rosette on dorsal side; lateral line complete but interrupted; barbels absent.

Keys to Species

(i) Anal fin rays below 25. .....(ii)

Anal fin rays above 25. .....(iii)

(ii) Pre-dorsal scales 12; lateral line with 38-40 scales; dorsal fin with 30-31 rays; pelvic fin length more than 50% of pectoral fin length. ....***Channa punctatus***

Pre-dorsal scales 7-8; lateral line with 41-43 scales; dorsal fin with 35-37 scales; length of pelvic fin less than 50% of pectoral fin. .....***Channa gachua***

(iii) A large black ocellus on caudal fin base; pre-dorsal scales 16-17, rows of back blotches or spots along the flank; anal fin ray 31-33. .....***Channa marulius***

No black ocellus on caudal fin base; body has several dark vertical bands below lateral line; anal fin rays 26-27. .....***Channa striatus***

***(a) Channa gachua* (Hamilton-Buchanan) (Fig. 50)**

Syns. 1822, *Ophiocephalus gachua*, Hamilton-Buchanan. *Fish. Ganges*, pp. 68, 367.

1878, *Ophiocephalus gachua*, Day. *Fish. India*, p. 367.

1959, *Channa gachua*, Misra. *Rec. Indian Mus.*, **57**: 218.

Fin formula: D. $_{35-37}$ A. $_{22-23}$ P. $_{14-15}$ V. $_{6}$

External Characters: Body elongated, its depth being 5.5 times in standard length; dorso-ventrally compressed head, its length being 3.1 times in standard length; snout obtuse or slightly rounded; anterior nostril tubular; eyes small, being 7 times in head length; maxilla reaches below the hind edges of eye-orbit; mouth large with inner row of teeth, widely separated and conical on lower jaw; vomer and palatine teeth also present; barbels absent; length of pelvic fin less than 50% of pectoral fin length; pectoral and caudal fins rounded; dorsal fin base quite larger than anal fin base; scales larger on head; 7-8 scales present; lateral line with 41-43 scales

interrupted or splits after 12th scale; lateral transverse scales 4/7.

Colour: Colour of the body varies according to the water in which they inhabits; body colour usually dark greenish on dorsal surface which becomes lighter towards ventral side; dorsal, caudal and anal fins slate-grey coloured with orange margin; pectorals with black base; a large ocellus with light edge sometimes present on the last five dorsal rays.

Location: Fatehabad.

(b) *Channa marulius* (Hamilton-Buchanan) (Fig. 51)

Syns. 1822, *Ophiocephalus marulius*, Hamilton-Buchanan. *Fish. Ganges*, pp. 65, 367, pl. 17, fig. 19.

1876, *Ophiocephalus marulius*, Day. *Fish. India*, p. 363, pl. 76, fig. 4.

1959, *Channa marulius*, Misra. *Rec. Indian Mus.*, **57**: 218.

1991, *Channa marulius*, Talwar and Jhingran. *Inland Fishes*, **2**: 1017.

1999, *Channa marulius*, Jayaram. *The Freshwater Fishes of The Indian Region*, p. 446, pl. 18, fig. 1.

Fin formula: $D._{52-54}$ $A._{31-32}$ $P._{18}$ $V._{6}$

Common Name: Sol, Gaint snakehead.

External Characters: Body elongated and cylindrical, its depth being 5 times in standard length; head dorso-ventrally compressed; eyes moderate, 8 times in head length; mouth large, cleft very wide, reaching well beyond eyes; villiform teeth in several row on the lower jaw and vomers; palatine teeth absent; anterior nostrils tubular; pectoral fins length half of head length; pelvic fins 2/3rd of pectorals; dorsal fin have larger base length than anal fin, their width being almost equal; caudal fin rounded; scales moderate sized on body, large and rosette shaped on head lying between inter-orbital region; lateral line complete with 65-68 scales, interrupted after 18th scale; pre-dorsal scales 16-17; lateral transverse scales 6/14-15 (with respect to upper lateral line).

Colour: Body greyish on dorsal side with silvery-white abdomen; series of 6-7 big black blotches along lateral line; a large black ocellus with white edge present on the upper end of caudal fin base; dorsal, anal and caudal fins with dotted white spots along with greyish-black fin margins.

Location: Kurukshetra, Ambala, Yamunanagar, Karnal, Panipat, Panchkula.

(c) *Channa punctatus* (Blotch) (Fig. 52)

Syns. 1793, *Ophiocephalus punctatus*, Blotch. *Naturges. Ansland. Fische*, (7): 139.

1822, *Ophiocephalus punctatus*, Hamilton-Buchanan. *Fish. Ganges*, pp. 63, 367.

1876, *Ophiocephalus punctatus*, Day. *Fish. India*, p. 367, pl. 78, fig. 1.

1959, *Channa punctatus*, Misra. *Rec. Indian Mus.*, **57**: 219.

1991, *Channa punctatus*, Talwar and Jhingran. *Inland Fishes*, **2**: 1020, fig. 290.

1999, *Channa punctatus*, Jayaram. *The Freshwater Fishes of The Indian Region*, p. 446, pl. 18, fig. 3.

Fin formula: $D._{30-31}$ $A._{21}$ $P._{17}$ $V._{6}$

Common Name: Daula, Spotted snakehead.

External Characters: Body elongated and cylindrical; its depth being 4.4-4.8 times in standard length; head dorso-ventrally compressed; eyes moderate being 7-8 times in head length; mouth large, terminal, slightly oblique; 3-6 canine teeth along with several rows of villiform teeth are present on jaws, vomer and palate; head covered with large angular scales; numerous cephalic sensory pits in the centre of head between eyes; 5-6 mandibular openings on the lower jaw; pelvic fins 2/3rd of pectoral fins and length of pelvic and minimum body depth of fish almost equal; pectoral and caudal fins rounded; large plate-like scales present on head as compared to the body, rosette-shaped arrangement of scales on inter-orbital region; lateral line scales 39, interrupted after 13-15 scale forming two rows; pre-dorsal scales 12; lateral line scales 4/9 (with respect to upper lateral line).

Colour: Body greyish-black to light greenish on dorsal side which progressively becomes lighter towards flank and becomes cream-white or pale yellow on abdomen; several dark big blotches on the flank arranged in the transverse rows above and below the lateral line; young specimens have reddish tinge abdomen; black dots in 3 rows present on dorsal and anal fin; caudal fin with six striations; colour of dorsal, anal and caudal fins dark grey with whitish tip; paired fins pale in colour or having light orangish tinge in fresh condition.

Location: Kurukshetra, Ambala, Yamunanagar, Karnal, Panipat, Hisar, Sirsa Fatehabad, Kaithal, Panchkula.

(d) *Channa striatus* (Blotch) (Fig. 53)

Syns. 1793, *Ophiocephalus striatus*, Blotch. *Naturges. Ansland. Fische*, (7): 141, pl. 359.

1876, *Ophiocephalus striatus*, Day. *Fish. India*, p. 366.

1959, *Channa striatus*, Misra. *Rec. Indian Mus.*, **57**: 219.

1991, *Channa striatus*, Talwar and Jhingran. *Inland Fishes*, **2**: 1022, fig. 291.

1999, *Channa striatus*, Jayaram. *The Freshwater Fishes of The Indian Region*, p. 446, pl. 18, fig. 4.

Fin formula: D. $_{43}$ A. $_{26\text{-}27}$ P. $_{16\text{-}17}$ V. $_{6}$

Common Name: Sowli, Striped snakehead.

External Characters: Body elongated, its depth being 6 times in standard length, fairly rounded in cross-section with slightly pointed snout; head dorso-ventrally compressed and covered with large angular scales; mouth large, terminal; cleft slightly oblique and hind end of maxilla reaching well beyond the eyes; inter-orbital space almost flat; canine teeth present on lower jaws along with villiform several rows of teeth on jaws, vomer and palatine; pectoral and caudal fins rounded; dorsal fin arises well in advance of ventral fin, long and spineless; pelvic fins almost 2/3rd in length of pectoral fins; scales moderate sized on body, large plate-like on head arranged in rosette-shaped; lateral line complete with 55-56 scales, not interrupted but bends slightly after 17th scale to 21st scale; lateral transverse scales 5$^{1/2}$-6/13; pre-dorsal scales 18-19.

Colour: Body dark coloured with greyish or blackish-green on dorsal side and progressively lighter towards ventral side; belly silvery-white; 14-15 black bands alternating with white bands on the dorsal side of body along with the dorsal fin; similar alternating light coloured bands on ventral side and anal fin also; a dark band runs obliquely form snout to the edge of operculum; several black dots present on the dorsal and caudal fin; pectoral and pelvic fins whitish; caudal fin also have distinct pale vertical bands at their base.

Location: Kurukshetra, Ambala, Yamunanagar, Karnal, Hisar, Panchkula.

DESCRIPTION OF THE GENERA OF ORDER SILURIFORMES

Subdivision : Euteleostei
Superorder : Ostariophysi
Order : Siluriformes
Family : Amblycipitidae

Genus: *Amblyceps* Blyth

1858, *Amblyceps*, Blyth. *Proc. Asiat. Soc. Bengal*, **27**: 282.

Body elongate, sub-cylindrical with more or less uniform depth; head small, depressed with soft skin; snout rounded; eyes very small superior, subcutaneous; mouth anterior or terminal, gape wide; villiform small teeth on jaws only; palatine teeth absent; lips fleshy; anterior dorsal fin enveloped in the fold of thick skin; a similar prominent and characteristic fold of skin anteior to the pectoral fin behind gill openings in which gill membranes rests; thoracic adhesive disc absent; barbels four pairs (one pair each of maxillary and nasal or rostral while two pairs of mandibular barbels); skin smooth with no lateral line; dorsal fin two- first dorsal fin having one spiny ray and other soft rays while second adipose dorsal fin without fin ray; generally inhabiting fast-moving streams.

***Amblyceps mangois* (Hamilton Buchanan) (Fig. 54)**

Syns. 1822, *Pimelodus mangois*, Hamilton-Buchanan. *Fish. Ganges*, pp. 199, 379.

1877, *Amblyceps mangois*, Day. *Fish. India*, p. 490, pl. 102, fig. 6.

1991, *Amblyceps mangois*, Talwar and Jhingran. *Inland Fishes*, **2**: 615.

1999, *Amblyceps mangois*, Jayaram. *The Freshwater Fishes of The Indian Region*, p. 266, fig. 137.

Fin formula: D. $_{I/6}$ A. $_{II/8}$ P. $_{I/7}$ V. $_{I/5}$

Common Name: Billi, Sundaal, Torrent catfish.

External Characters: Body elongated, sub-cylindrical with uniform width, its depth being 5.1-5.6 times in standard length in different specimens; head small, its length being 4.5-5.0 times in standard length, broad, slightly depressed and covered with soft but thick skin; mouth wide; lower jaw slightly produced forward; nostrils close together,

separated by nasal barbels; eyes small, on dorso-lateral side of head; barbels 4 pairs, nasal and inner mandibular pair are almost of same length; gill openings fairly wide having a fold of skin near its opening and base of pectoral fin in which gill-membrane rest when operculum is closed during rapid swimming; dorsal spine, weak and smooth, concealed under fold of skin on anterior side of 1st dorsal fin; 2nd dorsal fin also called *adipose fin* lacks fin rays, being smooth and of low depth; pectoral spine also concealed under fold of skin behind operculum; caudal fin deeply emarginated with longer upper lobe; scales absent; lateral line also absent; caudal peduncle not clearly distinct as covered mostly by caudal fin rays.

Colour: Body colour olive-brown with light brown ventral side (preserve specimens have uniform light brown colour); sometimes with lateral bands or a dark line commences opposite the operculum and soon subdivides (seen clearly in fresh specimens).

Location: Panchkula (Nada Sahib).

Superorder: Ostariophysi
Order : Siluriformes
Family : Bagridae
Subfamily : Bagrinae

Genus: *Sperata* Holly

1939, *Sperata* Holly, Zool. Anzeiger 125.

Dorsal profile arched, head large,elongate, slightly depressed, snout spatulate or rounded; jaws sub-equal; lips thin. Mouth sub-terminal, transverse, moderately wide. Teeth uniformly villiform on jaws and palate in bands.Eyes moderately large, supra lateral, A distinct inter-neural shield in between basal bone of dorsal fin and occipital process present, not suturally attached to the exposed surface of the first dorsal fin pterygiophore. Four pairs of barbells one each of maxillary, nasal, and two mandibular. Gill membranes free from each other, overlapping and also from isthmus.Branchiostegals 12. Rayed dorsal fin with seven rays and a robust spine. Adipose dorsal fin low its margin slightly convex. Pectoral fins with 9 or 10 rays and a spine serrated along inner edge with antrose teeth. Pelvic fin with 6 rays. Anal fin short with 11-15 rays. Caudal fin deeply forked. Lateral line complete, simple. A concavity on the posterior surface of the post-temporal into which an anterior extension of the air-bladder rests. Air – bladder with a complete longitudinal septum, an elongate maxilla. A large round or ovoid dark spot near the posterior of adipose fin present.

***Sperata seenghala* (Sykes) (Fig. 55)**

Syn. 1841, *Platystoma seenghala*, Sykes. *Trans. Zool. Soc. London*, **2**: 371, pl. 65, fig. 2.

1877, *Macrones seenghala*, Day. *Fish. India*, p. 444, pl. 99, fig. 1.

1976, *Mystus* (*Aorichthys*) *seenghala*, Misra. *Fauna of India,* Pisces (2nd ed.), **3**: 79, fig. 16.

1991, *Aorichthys seenghala*, Talwar and Jhingran. *Inland Fishes*, **2**: 548.

2010, *Sperata seenghala*, Jayaram. *The Freshwater Fishes of The Indian Region*, p. 240.

Fin formula: D. $_{I/7}$ A. $_{iii/9}$ P. $_{I/10}$ V. $_{i/5}$

Common Name: Singhara, Seenghari Tengara, River catfish.

External Characters: Body elongated, dorso-ventrally compressed anteriorly and laterally compressed posteriorly; its depth being 5.5-6 times in standard length; snout broad, depressed and spatulate; inter-neural shield present on nape; head large, depressed its length being 4.9 times in standard length; snout granulated in ridges; mouth wide, sub-terminal; upper jaw slightly projected ahead of lower jaw; villiform teeth on jaws, vomer and palatine; barbels 4 pairs, nasal pair shortest, maxillary pair extends beyond anal fin origin, 2nd mandibular barbels reaches opercular edge; dorsal spine weak, rough anteriorly but serrated posteriorly, its height being twice in its length; adipose fin base equal to rayed dorsal fin base; inter-distance between the two dorsal fins is equal to the individual depth of either fins; pectoral spine very strong with large denticulations on its inner surface, outer surface finely serrated; scales absent; lateral line distinct; caudal fin forked with longer upper lobe than lower; scales absent; lateral line distinct.

Colour: Body brownish-black on the dorsal side with silvery-white ventral surface below lateral line; a dark black spot present on the posterior basal part of the adipose fin; rayed dorsal fin have black margins; dorsal, pectoral and caudal fin dotted black; anal fin pale.

Location: Yamunanagar, Ambala, Karnal, Panipat.

Genus: *Mystus* Scopoli

1777, *Mystus*, Scopoli. *Introductio ad historium naturalem*, p. 151.

Body moderately elongated, laterally compressed; head moderated with slight depressed, rounded or obtuse snout; inter-neural shield absent; occipital process extends to the basal bone of the dorsal fin; mouth sub-terminal, fairly wide; villiform teeth in the form of bands on jaw and plate; upper jaw generally longer than lower; eyes moderate with free circular margin; barbels 4 pairs, generally longer than head except rostral or nasal; maxillary barbels are of varying length in different species; two dorsal fins, rayed dorsal fin with one serrated spine and 7 soft rays, adipose dorsal fin is of varying length in different species; pectoral fins with a strong serrated spine; caudal fin forked or deeply emarginated with rounded unequal lobes; scales absent; lateral line complete.

Keys to Species

(i) Maxillary barbels reaches to pelvic fin; adipose dorsal fin starts from the base of the last undivided dorsal ray and 3 times in length of rayed dorsal fin; body with 4-5 black longitudinal bands. ..... ***Mystus tengara***

Maxillary barbels extend beyond the pelvic fin. .....(ii)

(ii) Maxillary barbels reaches upto caudal fin base or beyond; no longitudinal bands on body; a dark blotch at the base of dorsal fin. ..... ***Mystus cavasius***

Maxillary barbels reaches only upto the anal fin; body with two light longitudinal bands one each above and below the lateral line; no dark spot at the base of dorsal fin. ..... ***Mystus bleekeri***

(a) *Mystus bleekeri* (Day) (Fig. 56)

Syns. 1877, *Macrones bleekeri*, Day. *Fish. India*, p. 451, pl. 101, fig. 1.

1976, *Mystus (Mystus) bleekeri*, Misra. *Fauna of India*, Pisces (2nd ed.), **3**: 85, fig. 17.

1991, *Mystus bleekeri*, Talwar and Jhingran. *Inland Fishes*, **2**: 558, fig. 183.

1999, *Mystus bleekeri*, Jayaram. *The Freshwater Fishes of The Indian Region*, pp. 235, 239, fig. 118D.

Fin formula: D. $_{I/7}$ A. $_{iii/8}$ P. $_{I/9}$ V. $_{i/5}$

Common Name: Kander, Keengar.

External Characters: Body elongated and laterally compressed, its depth being 4-4.5 times in standard length; head moderate and slightly depressed, its length being 4.1-4.3 times in standard length; occipital process reaching at the basal bone of dorsal fin; median longitudinal groove narrow, constricted in the middle and reaches the base of occipital process; eyes moderate sized; mouth terminal; villiform teeth in the form of bands on jaws and palate but vomerine teeth slightly curved and continuous; barbels 4 pairs, (maxillary pair reaches upto anal fin while outer mandibular pair reaches upto pectoral fins); operculum and shoulder bones fine granulated; radiating lines emerges from operculum towards posterior end of body; rayed dorsal fin spine weak and smooth; pectoral fin spines strong, having denticulations on its inner edge; adipose dorsal fin have larger base, low commencing just behind rayed dorsal fin and covering 2/3rd length of caudal peduncle; caudal fin forked with longer and pointed epicordal lobe while hypocordal lobe shorter and rounded; scales absent; lateral line visible and complete.

Colour: Body greyish-brown on dorsal side, progressively lighter below; two light coloured longitudinal bands, one above and below the lateral line, clearly distinct; a dark blotch at the base of caudal fin and other similar on the shoulder; fins spotted; adipose fin margin slightly blackish in fresh specimens.

Location: All over Haryana.

(b) *Mystus cavasius* (Hamilton-Buchanan) (Fig. 57)

Syns. 1822, *Pimelodus cavasius*, Hamilton-Buchanan. *Fish. Ganges*, pp. 203, 379, pl. 11, fig. 67.

1877, *Macrones cavasius*, Day. *Fish. India*, p. 447, pl. 100, fig. 1.

1976, *Mystus (Mystus) cavasius*, Misra. *Fauna of India*, Pisces (2nd ed.), **3**: 87, fig. 18.

1991, *Mystus cavasius*, Talwar and Jhingran. *Inland Fishes*, **2**: 558, fig. 184.

1999, *Mystus cavasius*, Jayaram. *The Freshwater Fishes of The Indian Region*, pp. 235, 239, fig. 118C.

Fin formula: D. $_{I/7}$ A. $_{iii-iv/8}$ P. $_{I/8}$ V. $_{i/5}$

Common Name: Keengar.

External Characters: Body more or less elongated, laterally compressed with a its depth approximately 4.8-5 times in standard length; head 4.5 times in standard length, slightly depressed; occipital process narrow reaching extending upto dorsal fin base; median longitudinal groove broad, constricted in the middle and reaches the base of occipital process; eyes moderate; mouth terminal; upper jaw slightly forward; villiform teeth in the form of bands on jaws, vomer and palate; barbels 4 pairs, (maxillary pair extends beyond caudal fin base, inner mandibular barbels reaches upto pectorals while outer mandibulars reaches pelvic fin origin); rayed dorsal fin with weak smooth spine; adipose dorsal fin starts behind rayed dorsal and is of 3 times in length than latter; pectoral spines strong and serrated internally; caudal fin deeply forked with longer and pointed upper lobe; scales absent; lateral line distinctly visible.

Colour: Body colour slate-greyish on dorsal side; lighter below; belly silvery-grey; black blotch near the operculum which elongates into mid-lateral stripe on the flank; base of dorsal spine also have a black spot; dorsal and caudal fin dotted brown; pectorals, pelvics and anal fin pale.

Location: Panchkula, Yamunanagar and Ambala.

(c) *Mystus tengara* (Hamilton-Buchanan) (Fig. 58)

Syns. 1822, *Pimelodus tengara*, Hamilton-Buchanan. *Fish. Ganges*, pp. 183, 377, pl. 23, fig. 6.

1877, *Macrones tengara*, Day. *Fish. India*, p. 447, pl. 101, fig. 5.

1976, *Mystus* (*Mystus*) *tengara*, Misra. *Fauna of India,* Pisces (2nd ed.), **3**: 104.

1991, *Mystus tengara*, Talwar and Jhingran. *Inland Fishes*, **2**: 571, fig. 189.

1999, *Mystus tengara*, Jayaram. *The Freshwater Fishes of The Indian Region*, p. 236.

Fin formula: D. $_{I/7}$ A. $_{ii/9-10}$ P. $_{I/8}$ V. $_{I/5}$

Common Name: Tengra, Tinger.

External Characters: Body elongated, laterally compressed, its depth being 4.3 times in standard length; head blunt, moderate sized, its length being 3.9 times in standard length; median longitudinal groove on head extending upto occipital process which in turn reaches upto basal bone of dorsal fin; eyes moderate, being 4.5-4.7 times on head length; mouth terminal; jaws more or less equal; villiform teeth on jaws, palate and vomerine; barbels 8, (maxillary barbels extends upto base of pelvic fins); rayed dorsal spine smooth, sometimes serrated on its posterior edge; adipose dorsal fin long and started behind rayed dorsal fin; pectoral spines strong and serrated internally; anal fin almost of same length and height; caudal fin deeply emarginated or forked; scales absent; lateral line distinct.

Colour: Body colour gently greenish-grey on dorsal side to bright yellow-white on flank; belly off-white in colour; four longitudinal grey-green bands on flank covered with black dots which tapers towards posterior side and eventually disappears on caudal peduncle; a dark blotch or spot on shoulder, fins dotted brown and hyaline, slightly bluish in fresh condition.

Location: Panchkula (Nada Sahib).

Superorder: Ostariophysi

Order : Siluriformes

Family : Clarridae

Genus *Clarias* Scopoli

1777, *Clarias*, Scopoli.
Introductio ad Historium Naturalam, p. 445.

Body elongated, laterally compressed; head moderate sized, highly depressed, covered with osseous plates on dorsal side; gape of mouth moderate; snout pointed or slightly rounded; gill membranes not joined with isthmus; eyes small, on dorsal side, with free circular margin, not visible below the head; dendritic accessory breathing apparatus present on 2nd and 4th branchial arches; barbels four pairs; teeth villiform on jaw and in bands across the vomer; dorsal and anal fins having long bases; dorsal and anal fins having long bases, reaching almost upto caudal fin base, spineless; adipose dorsal fin absent; pectoral fin well developed with a strong serrated spine; ventral fin well developed with six rays; scales absent; lateral line distinct.

Key to Species

(a) Dorsal fin ray count more than 70; body colour dark; nasal and inner mandibular barbel are of same size. ..... ***Clarius batrachus***

(b) Dorsal fin slightly shorter with less than 70 fin rays; body colour lighter; nasal and mantle

barbels are not of same length. .....
.....***Clarius gariepinus***

(a) *Clarius batrachus* (Linnaeus) (Fig. 59)

Syns. 1758, *Silurus batrachus*, Linnaeus. *Systema Naturae*, (ed. 10), **1**: 305.

1822, *Macropteronotus magur*, Hamilton-Buchanan. *Fish. Ganges*, pp. 146, 374.

1877, *Clarias magur*, Day. *Fish. India*, p. 485, pl. 112, fig. 5.

1959, *Clarius batrachus*, Misra. *Rec. Indian Mus.*, **57**: 186.

1991, *Clarius batrachus*, Talwar and Jhingran. *Inland Fishes*, **2**: 684, fig. 218.

1999, *Clarius batrachus*, Jayaram. *The Freshwater Fishes of The Indian Region*, p. 303, fig. 155.

Fin formula: D. $_{70-74}$ A. $_{52-54}$ P. $_{I/9}$ V. $_{I/5}$

Common Name: Magur, Mangur.

External Characters: Body elongated with highly compressed lateral sides, its depth being 6 times in standard length; dorso-ventrally depressed and moderate head, its length being 3.5-4.2 in standard length; occipital process narrow; mouth terminal, cleft wide; villiform teeth on jaws, vomerine teeth villiform or globular and in form of bands; eyes small, not visible underneath the head; inter-orbital space straight; barbels 8, maxillary not reaching dorsal fin origin, but beyond pectoral fin; nasal and inner mandibular are almost of same size; dorsal fin arises slightly anterior to the margin of pectorals; pectoral fin with strong, finely serrated on its both edges, covered under skin; pelvic fins originated behind the dorsal fin origin; dorsal and anal fin quite long reaching almost the caudal fin base; adipose dorsal fin absent; caudal fin rounded; scales absent; lateral line distinctly visible.

Colour: Body brownish-black in colour with dorsal surface more darker in shade; flank and belly brownish to light reddish-brown in colour with pale irregular dark spots; dorsal and anal fins usually with reddish-brown tinge; small specimens are copper red or dark brown in appearance.

Location: Panipat, Karnal, Fatehabad.

(b) *Clarius gariepinus* (Burchell) (Fig. 60)

Syns. 1822, *Clarius gariepinus*, Burchell. *Fish. Ganges*, pp. 146, 374.

Fin formula: D. $_{68-70}$ A. $_{53-57}$ P. $_{I/8-9}$ V. $_{I/5}$

Common Name: Thai Magur, Thai Mangur.

External Characters: Body elongated, laterally compressed with a depth of 6.25 times in standard length; head 4 times in standard length, dorso-ventrally depressed with slightly rounded and coarsely granulated snout; occipital process narrow; mouth terminal; cleft wide; gape moderate; eyes small, not visible underneath the head; inter-orbital space straight; barbels 4 pairs, maxillary quite long but not reaching dorsal fin origin; nasal and inner mandibular barbles are not of same length; dorsal fin spineless, long and reaching upto the base of caudal fin; pectoral spine serrated only on its outer side; adipose dorsal fin absent; caudal fin rounded; scales absent; lateral line distinct.

Colour: Body generally dark with greyish-black dorsal surface and creamy- white belly or ventral side; a distinct black longitudinal band on ventral side of head (present in fresh condition in adults only); older specimens have grey-khaki dorsal surface.

Location: Panipat.

Superorder: Ostariophysi

Order : Siluriformes

Family : Siluridae

Genus: *Wallago* Bleeker

1851, *Wallago*, Bleeker.
Nat. Tijdschr. Nederl. Inde., **2**: 265.

Body elongated, laterally compressed; head fairly large, depressed, covered with soft skin; mouth oblique, its cleft extending beyond eyes, snout produced forward, jaws unequal with lower jaw little longer then upper, giving it a spatulate appearance; eyes small, above the level of angle of mouth, having free orbital margin, not visible underside the head; lips thin; villiform teeth on jaws, vomerine teeth in patches, palate teeth absent; barbels 4, (2 maxillary and 2 mandibular), rostral barbels absent; dorsal fin short, spineless with five rays and arises half the length of pectoral fin and in advance to pelvics; adipose dorsal fin quite longer, terminating near caudal fin base; caudal fin forked with rounded corners and larger upper lobe; lateral line complete and distinctly visible, scales absent.

Wallago attu (Schneider) (Fig. 61)

Syns. 1801, *Silurus attu*, Schneider. *Syst. Ichthy.*, p. 378, pl. 75.

1822, *Silurus attu*, Hamilton-Buchanan. *Fish. Ganges*, pp. 154, 375.

1877, *Wallago attu*, Day. *Fish. India*, p. 479, pl. 111, fig. 4.

1959, *Wallago attu*, Misra. *Rec. Indian Mus.*, **57**: 180.

1991, *Wallago attu*, Talwar and Jhingran. *Inland Fishes*, **2**: 590.

1999, *Wallago attu*, Jayaram. *The Freshwater Fishes of The Indian Region*, p. 246, fig. 122.

Fin formula: D. $_{I/4}$ A. $_{88\text{-}90}$ P. $_{I/13\text{-}14}$ V. $_{I/8\text{-}9}$

Common Name: Mullee, Freshwater Shark.

External Characters: Body elongated, slightly compressed; head depressed; mouth large sized, wide, terminal in position, oblique with slightly longer lower jaw; its cleft reaching beyond eyes; snout obtusely rounded and spatulate; eyes small, with free orbital margins present in front of vertical through corners of mouth, wide apart; inter-orbital space slightly convex; teeth large, numerous, pointed, depressible and in the form of bands on jaws, vomerine teeth in two small patches; barbels two pairs, maxillary pair reaches beyond the anterior part of anal fin, mandibular pair extending to the angles of mouth and almost equals to the snout length; dorsal fin very short as compared to anal, inserted in advance to ventral fin origin; anal fin very long (resembling blade of the sword), reaching upto to the caudal fin base; pectoral spine weak with no denticulations or poorly serrated internally; caudal fin deeply forked with rounded lobes, upper lobe being larger than the lower one.

Colour: Body colour silvery with dorsal side greenish or reddish-brown or brownish-black in colour with little golden gloss; flank and belly dull white; fins spotted black especially anal and caudal fins dusky in appearance.

Location: Yamunanagar (Dadupur Headworks), Ambala, Karnal, Panipat.

Superorder : **Ostariophysi**

Order : **Siluriformes**

Family : **Heteropneustidae**

Genus: *Heteropneustes* Muller

1840, *Heteropneustes*, Muller. *Arch. Anat. Physiol.*, p. 115.

Body elongated and compressed laterally, especially towards ventral side; head moderate, greatly depressed, covered with bony plates on dorsal and lateral side; snout almost flat; mouth terminal; transverse and narrow; eyes small with free circular margin and dorsally placed on head; jaws slightly unequal; lips thick, fleshy and papillated; villiform teeth bands present on jaws and in oval patches on vomer; gill membranes separated by a notch; gill cavity having an accessory respiratory sac, serving as lung, extends backward on either side of neural spines between themselves of abdominal and caudal region; barbels 8, more or less of same size (one pair each of maxillary and rostral while two pairs of mandibular); rayed dorsal fin short and spineless inserted above pectoral fin tip; adipose dorsal fin absent; each ventral fin have six rays and situated right below the dorsal fin; pectoral fins with a strong spine, serrated on its inner edge; anal fin long, either reaching or confluent with caudal fin; caudal fin rounded; caudal peduncle absent; scales absent; lateral line simple and complete.

Key to Species

(a) Anal fin seperated from caudal fin by a deep notch. ..... ***Heteropneustes fossilis***

(b) Anal fin completely merged with caudal fin. ..... ***Heteropneustes microps***

(a) *Heteropneustes fossilis* (Bloch) (Fig. 62)

Syns. 1794, *Silurus fossilis*, Bloch. *Naturgesche. Ausl. Fische*, **8**: 46, pl. 370, fig. 2.

1822, *Silurus singii*, Hamilton-Buchanan. *Fish. Ganges*, pp. 147, 374.

1877, *Saccabranchus fossilis*, Day. *Fish. India*, p. 486, pl. 114, fig. 1.

1959, *Heteropneustes fossilis*, Misra. *Rec. Indian Mus.*, **57**: 185; Misra, 1976. *Fauna of India*, Pisces (2nd ed.), **3**: 135, fig. 24.

1991, *Heteropneustes fossilis*, Talwar and Jhingran. *Inland Fishes*, **2**: 689, fig. 219.

1999, *Heteropneustes fossilis*, Jayaram. *The Freshwater Fishes of The Indian Region*, p. 305, fig. 156A.

Fin formula: D. $_{6}$ A. $_{62\text{-}64}$ P. $_{I/7}$ V. $_{I/5}$

Common Name: Singhe, Singii, Stinging catfish.

External Characters: Body elongated, laterally compressed sharply behind anal fins; head moderate and equal to maximum body depth, being 5.9 times in standard length, dorsoventrally depressed; occipetal process not extending to base of dorsal fin; mouth small, transverse and terminal with slightly unequal jaws; villiform, sharp crowned teeth on jaws; four pairs of well developed barbels present, nasal being smallest of them; maxillary barbels extends beyond pectoral fins; outer mandibulars slightly shorter than maxillary barbels; rayed dorsal fin short, inserted above pelvic fins with six rays, no spine; pectoral fin with strong, serrated spines; anal fin not continuous with the caudal fin having a visible notch; caudal fin rounded; scales absent; lateral line distinct.

Colour: Body uniformly dark purplish-brown or reddish-brown in colour with dorsal surface darker than ventral side; two lateral yellowish bands along the flank; young specimens are dark reddish in colour.

Location: Hisar, Fatehabad.

(b) *Heteropneustes microps* (Gunther) (Fig. 63)

Syns. 1864, *Heteropneustes microps*, Gunther. *Cat. Fishes Br. Mus.*, **5**: 31.

1877, *Heteropneustes microps*, Day. *Fish. India*, p. 486.

1976, *Heteropneustes microps*, Misra. *Fauna of India*, Pisces (2nd ed.), **3**: 137.

1988, *Heteropneustes microps*, Dutta Munshi and Srivastava. *Natural History of Fishes and Systematics of Freshwater Fishes of India*, p. 298, pl. 37, fig. 2.

1991, *Heteropneustes microps*, Talwar and Jhingran. *Inland Fishes*, **2**: 690.

1999, *Heteropneustes microps*, Jayaram. *The Freshwater Fishes of The Indian Region*, p. 305, fig. 156B.

Fin formula: D. $_{7}$ A. $_{68\text{-}70}$ P. $_{I/6}$ V. $_{I/5}$

Common Name: Singhi, Sri Lankan stinging catfish.

External Characters: Body elongated, its depth being 6.5 times in standard length and compressed laterally similar to *H. fossilis*; head moderate, its length being 5.6 times in standard length, depressed; occipital process extending upto base of dorsal fin; mouth terminal, transverse and small; villiform sharp teeth in the form of bands present on jaws; vomerine teeth in patches; barbels 4 pairs, well-developed; outer mandibular and maxillary barbels are almost of same size; rostrals being shortest among them; dorsal fin short, without spine, inserted above pelvic fin; pectoral fins with a strong, highly serrated spine along its inner edge and few serrations on outer edge; anal fin very long and confluent with the caudal fin; caudal fin rounded; scales absent; lateral line distinctly visible.

Colour: Body colour dark purplish-brown or reddish-brown on dorsal surface which slightly becomes lightly towards ventral side; two light yellow lateral bands on flank, not very clear.

Location: Hisar.

Superorder : Ostariophysi

Order : Siluriformes

Family : Sisoridae

Genus: *Glyptothorax* Blyth

1861, *Glyptothorax*, Blyth. *J. Asiat. Soc. Beng.*, **29**: 154.

Body streamlined with elongated and laterally compressed behind pectoral fin, smooth or rough with tubercles and granules; head highly flattened dorso-ventrally, covered with thick skin; eyes small, towards dorsal side, covered with skin membrane; mouth transverse, inferior and narrow; lips thick and fleshy, papillated; jaws unequal with upper jaw longer than lower; teeth in the upper jaw arranged in a crescentic band, lower jaw teeth villiform, palatine teeth absent; chest with U or V-shaped thoracic adhesive apparatus composed of longitudinal muscular folds of skin, sometimes with a central pit of depression in the middle; barbels 8 (small as compared to other Siluriformes), maxillary pair with broad bases while rostral or nasal pair and two mandibular pairs are normal; gill membranes joined with the skin by isthmus, gill openings wide; rayed dorsal fin have short base but high; pectoral fins are strong, slightly broad with a sharp internally denticulated or serrated spines (sometimes enveloped under skin); pelvic fin situated considerably behind the dorsal fin origin but serving as a part of adhesive apparatus; caudal fin deeply forked; scales absent; lateral line well developed and visible. Mostly inhabiting fast moving streams and rivers.

Key to Species

(a) Body surface rough and wrinkled with granules or tubercles; dorsal spine strong and serrated on its inner edge. ..... ***Glyptothorax indicus***

(b) Body surface plain and devoid of colour bands, dorsal spine weak and smooth. ..... ***Glyptothorax telchitta***

(a) *Glyptothorax indicus* Talwar, *nom. nov.* (Fig. 64)

Syns. 1937, *Glyptothorax horai*, Shaw and Shebbeare. *J. Bombay Nat. Hist. Soc.*, **36**: 139.

1976, *Glyptothorax horai*, Misra. *Fauna of India*, Pisces (2nd ed.), **3**: 266.

1976, *Glyptothorax horai*, Tilak and Tandon. *Res. Bull. Panjab Univ.*, **21**(2/3), 503, figs. 1 and 2.

1991, *Glyptothorax indicus*, Talwar and Jhingran. *Inland Fishes*, **2**: 654, fig. 210.

1999, *Glyptothorax indicus*, Jayaram. *The Freshwater Fishes of The Indian Region*, p. 289.

Fin formula: D. $_{I/6}$ A. $_{ii/8}$ P. $_{I/8-9}$ V. $_{i/5}$

Common Name: Sunny.

External Characters: Body streamlined with elongated, laterally compressed behind pectoral fin, its depth being 4.8-5.7 times in standard length; dorsal profile more convex than ventral which is almost flat; head highly depressed, its length being 3.6-4.0 times in standard length; occipital process not reaching dorsal fin base; snout broad and rounded anteriorly; eyes small, subcutaneous and horizontally placed on dorsal side; mouth inferior, transverse with longer upper jaws; barbels four paired, maxillary barbels longer with broad base and reaches upto pectoral fin origin, nasal or rostrals reaching anterior end of eyes; outer mandibular half or 2/3rd in length of the maxillary barbels, inner mandibular less than half; well-defined adhesive apparatus on the thorax in between bases of pectoral fin, arrowhead shaped and devoid of central pit; dorsal fin inserted nearer to adipose fin than to snout-tip, its height less than maximum body width, its spine strong and serrated on its inner edge; pectoral fins spine flat with strong denticulations on posterior end; caudal fin deeply forked; scales absent; lateral line distinct.

Colour: Body colour dusky brown on dorsal side with many black irregularly scattered spots, ventral side dirty yellow or light brown in colour; a dark blotch on the shoulder and caudal fin base, dorsal fin brown with white margins; tip of caudal and anal fin dark.

Location: Panchkula (Nada Sahib).

(b) *Glyptothorax telchitta* (Hamilton-Buchanan) (Fig. 65)

Syns. 1822, *Pimelodus telchitta*, Hamilton-Buchanan. *Fish. Ganges*, pp. 185, 378.

1877, *Glyptosternum telchitta*, Day. *Fish. India*, p. 498, pl. 116, fig. 2.

1949, *Glyptothorax telchitta*, Hora and Manon. *Rec. Indian Mus.*, **46**(1): 57, pl. 2, figs. 1, 2 and 3.

1976, *Glyptothorax telchitta*, Misra. *Fauna of India*, Pisces (2nd ed.), **3**: 281, pl. 12, figs. 2, 3 and 4.

1991, *Glyptothorax telchitta*, Talwar and Jhingran. *Inland Fishes*, **2**: 663.

1999, *Glyptothorax telchitta*, Jayaram. *The Freshwater Fishes of The Indian Region*, p. 290, pl 14, fig. 3.

Fin formula: D. $_{I/6}$ A. $_{ii/10}$ P. $_{I/9}$ V $_{i/5}$

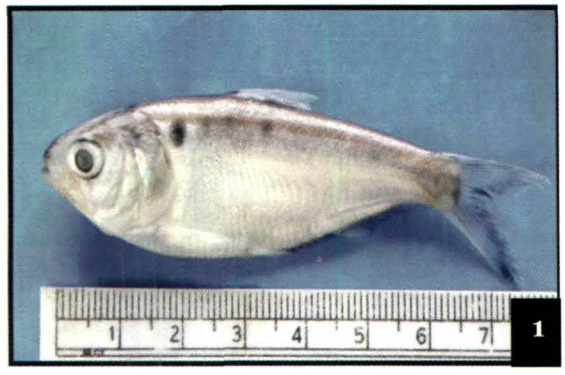
Common Name: Patharchat

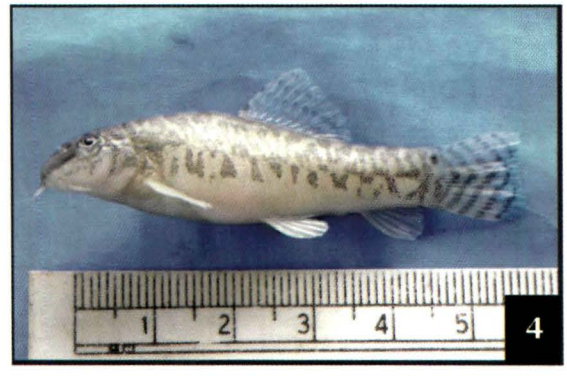
External Characters: Body slightly spindle-shaped i.e. streamlined, slender laterally compressed with narrow caudal peduncle, its depth being 6.5 times in standard length; dorsal profile more convex than ventral; head depressed, its length being 4.4 times in standard length; snout bluntly pointed; eyes very small, subcutaneous, dorso-lateral in position; inter-orbital slightly convex; occipital process not extending upto dorsal fin base; mouth sub-terminal or inferior; lips papillated; prominent tubercles on head and body; a thoracic adhesive apparatus without a median depression or central pit present; barbels 4 pairs, small; maxillary barbels longer reaching to anterior end of eye-orbit; dorsal fin more near to adipose dorsal fin than to snout-tip, dorsal spine weak and smooth; depth of anal and dorsal fin almost equal; length of pelvic fin equal to the maximum body depth; caudal fin deeply forked; least depth of caudal peduncle 3.25 times in length; scales absent; lateral line not distinct or incomplete.

Colour: Body of the fish dark brown to cement-grey

Fish species diversity of Haryana State

Plate I

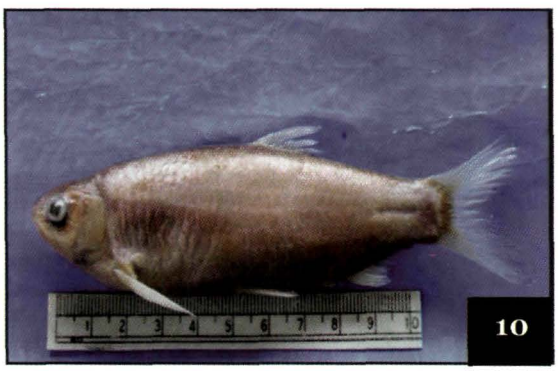


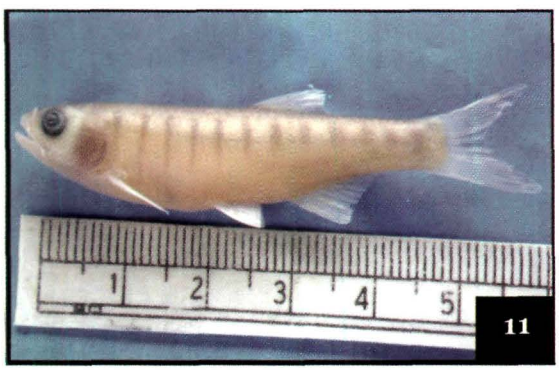


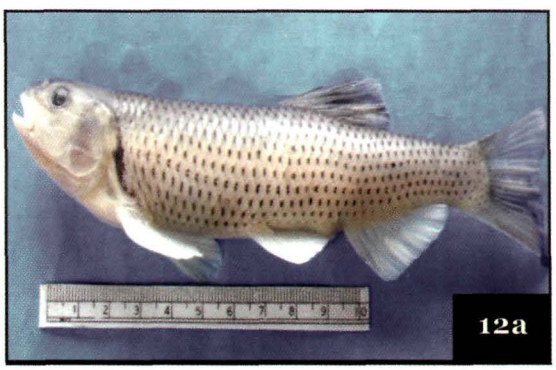
1. *Gudusia chapra* (Hamilton)
2. *Botia birdi* Chaudhuri
3. *Lepidocephalus guntea* (Hamilton)
4. *Nemacheilus botia* (Hamilton)
5. *Nemacheilus corica* Day
6. *Nemacheilus punjabensis* Hora

Fish species diversity of Haryana State

Plate II



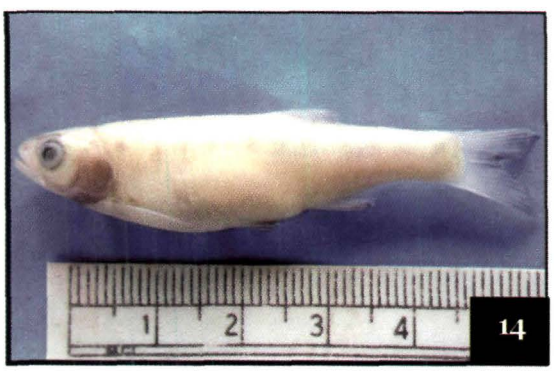


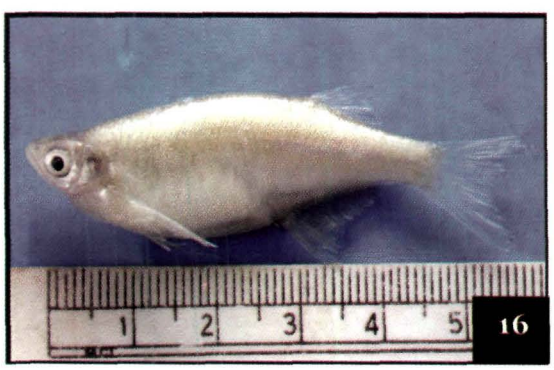


7. *Hypophthalmichthys molitrix* (Valenceinnes)
8. *Hypophthalmichthys nobilis* (Richardson)
9. *Amblypharyngodon mola* (Hamilton)
10. *Aspidoparia morar* (Hamilton)
11. *Barilius barila* (Hamilton)
12a. *Barilius bendelisis* var. *cocsa* (Hamilton)

Fish species diversity of Haryana State

Plate III





12b. *Barilius bendelisis* var. *chedra* (Hamilton)

13. *Barilius shacra* (Hamilton)

14. *Barilius vagra* (Hamilton)

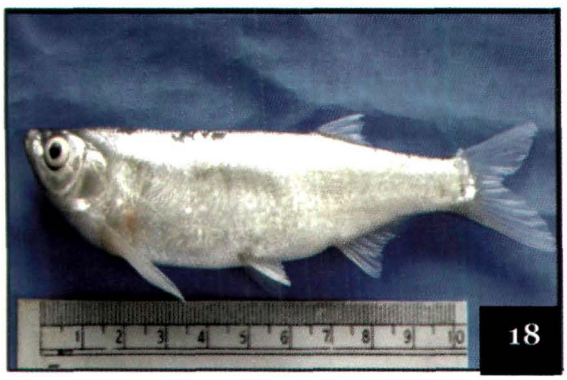
15. *Raiamas bola* (Hamilton)

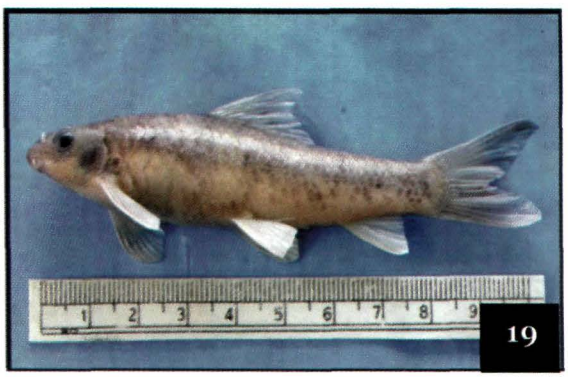
16. *Chela cachius* (Hamilton)

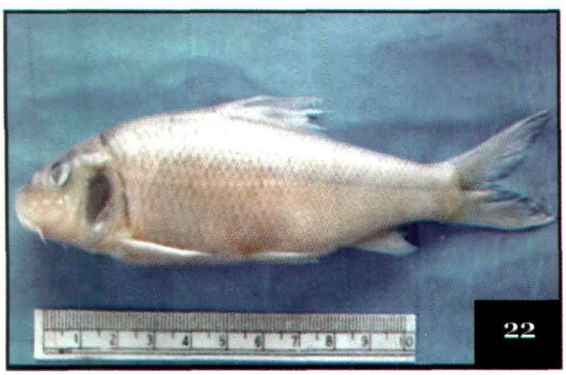
17. *Salmostoma bacaila* (Hamilton)

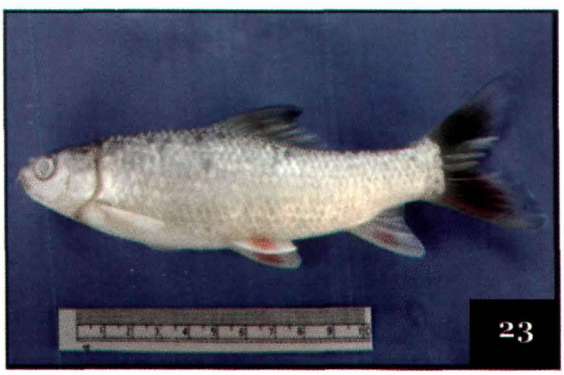
Fish species diversity of Haryana State

Plate IV





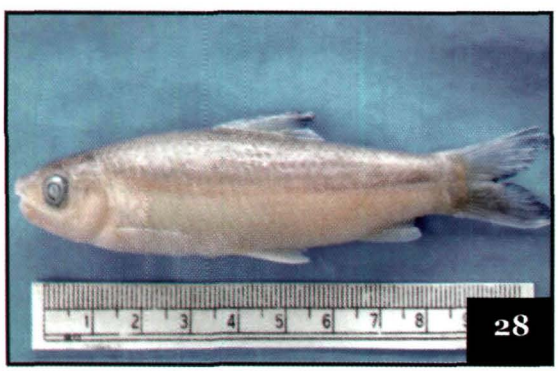




18. *Salmostoma phulo punjabensis* (Day)
19. *Crossocheilus latius diplocheilus* (Heckel)
20. *Garra gotyla gotyla* (Grey)
21. *Catla catla* (Hamilton)
22. *Chugunius chagunio* (Hamilton)
23. *Cirrhinus mrigala* (Hamilton)

Fish species diversity of Haryana State

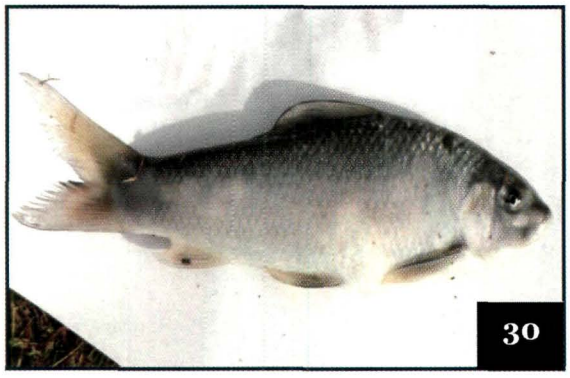
Plate V

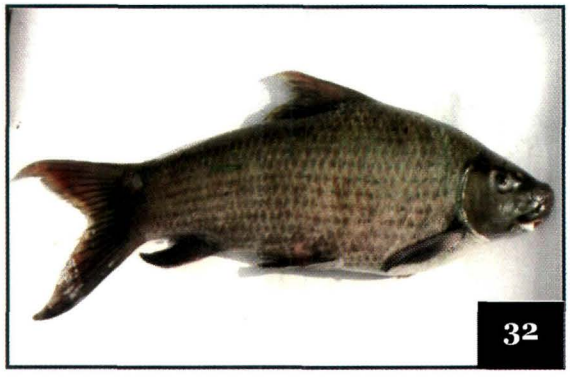


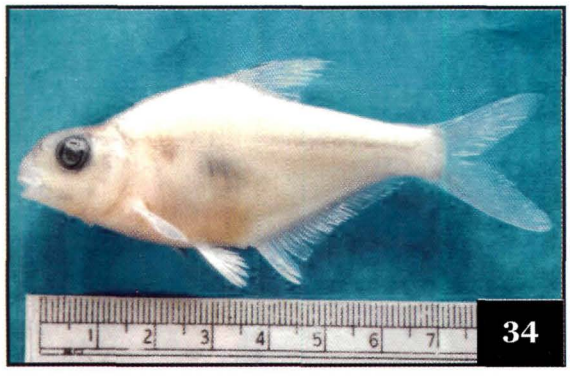
24. *Cirhhinus reba* (Hamilton)
25. *Ctenopharyngodon idellus* (Valenciennes)
26. *Cyprinus carpio* var. *communis* Linnaeus
27. *Cyprinus carpio* var. *specularis* Lecepede
28. *Labeo angra* (Hamilton)
29. *Labeo bata* (Hamilton)

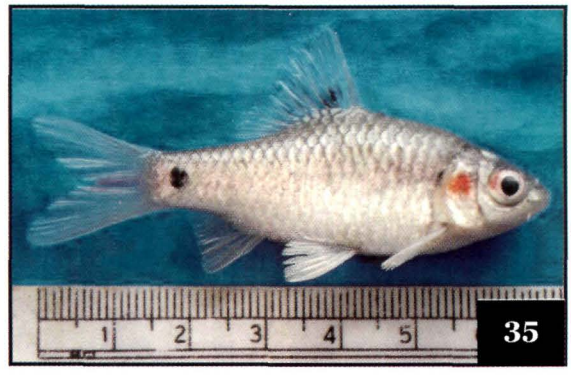
Fish species diversity of Haryana State

Plate VI









30. *Labeo calbasu* (Hamilton)

31. *Labeo dero* (Hamilton)

32. *Labeo dyocheilus* (McClelland)

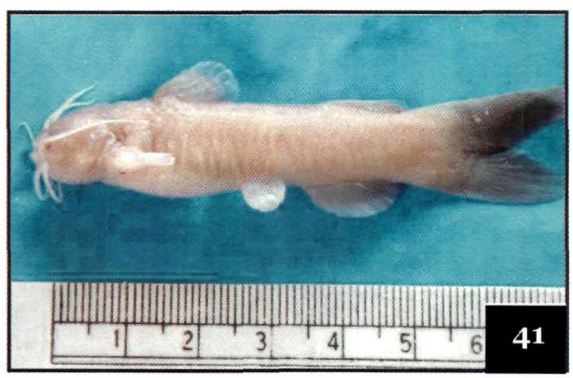
33. *Labeo rohita* (Hamilton)

34. *Osteobrama cotio* (Hamilton)

35. *Punitius chola* (Hamilton)

Fish species diversity of Haryana State

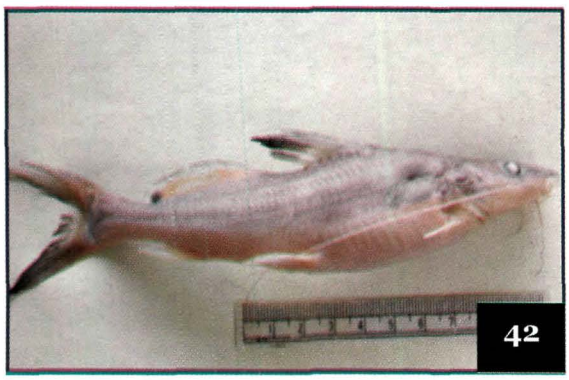
Plate VII

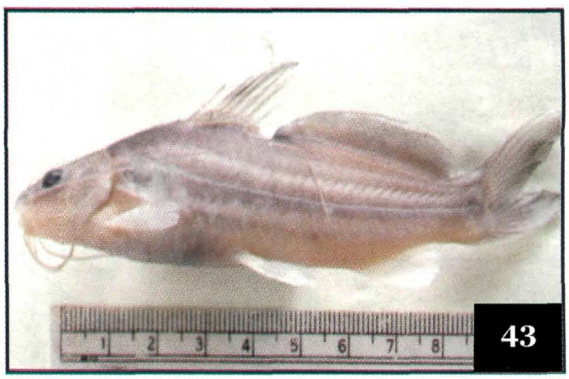


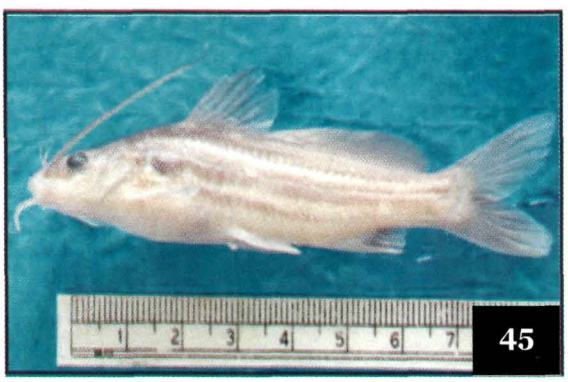
36. *Puntius sarana sarana* (Hamilton)
37. *Puntius sophore* (Hamilton)
38. *Puntius terio* (Hamilton)
39. *Puntius ticto* (Hamilton)
40. *Tor putitora* (Hamilton)
41. *Amblyceps mangois* (Hamilton)

Fish species diversity of Haryana State

Plate VIII



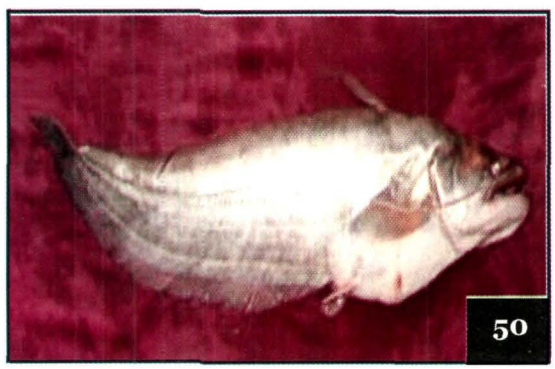


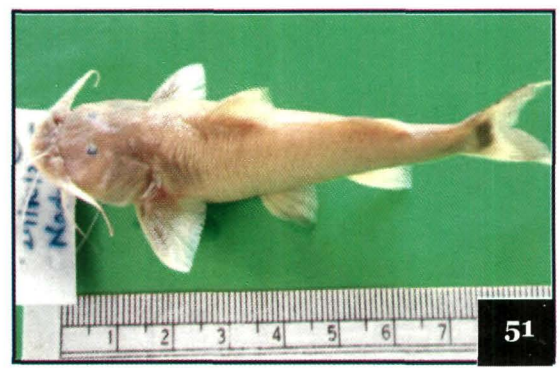


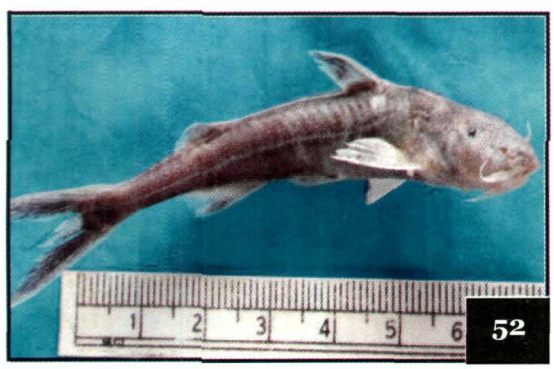
42. *Aorichthys seenghala* (Sykes)
43. *Mystus bleekeri* (Day)
44. *Mystus cavasius* (Hamilton)
45. *Mystus tengara* (Ham.)
46. *Clarias batrachus* (Linnaeus)
47. *Clarias gariepinus* (Burchell)

Fish species diversity of Haryana State

Plate IX



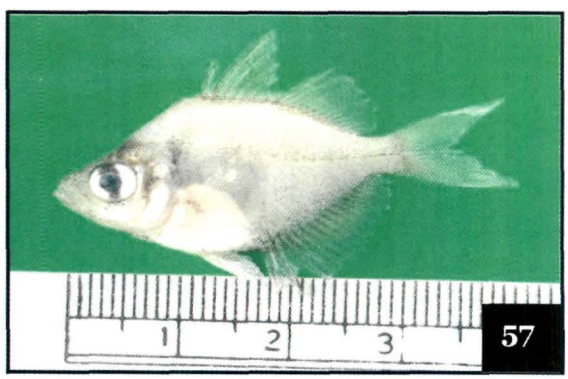




48. *Heteropneustes fossilis* (Bloch)
49. *Heteropneustes microps* (Gunther)
50. *Wallago attu* (Bloch)
51. *Glyptothorax indicus* Talwar
52. *Glyptothorax telchitta* (Hamilton)
53. *Xenentodon cancila* (Hamilton)

Fish species diversity of Haryana State

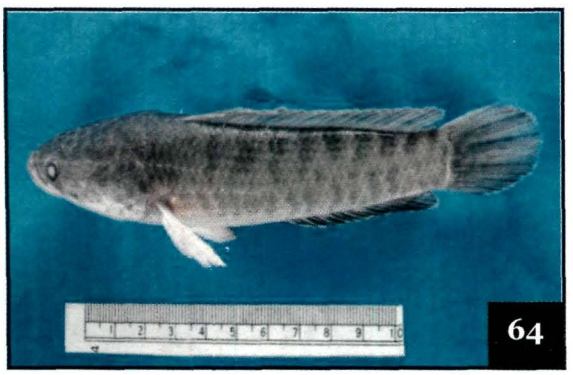
Plate X

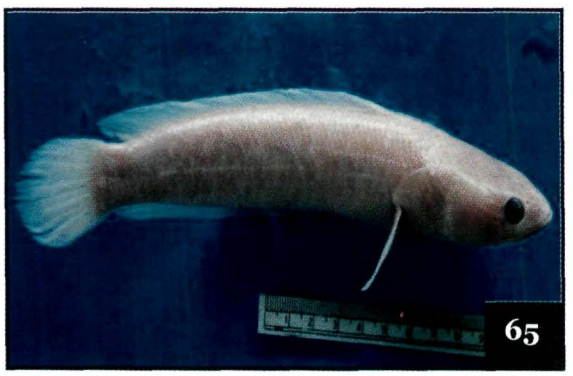


54. *Gambusia affinis* (Baird & Girard)
55. *Mastacembelus armatus* (Lecepede)
56. *Chanda nama* Hamilton
57. *Parambassis ranga* (Hamilton)
58. *Oreochromis mossambica* (Peters)
59. *Glossogobius giuris giuris* (Hamilton)

Fish species diversity of Haryana State

Plate XI





60. *Anabas testudineus* (Bloch)
61. *Colisa fasciatus* (Schneider)
62. *Channa marulius* (Hamilton)
63. *Channa orientalis* Bloch & Schneider
64. *Channa punctatus* (Hamilton)
65. *Channa striatus* (Bloch)

towards dorsal surface, creamy or dirty yellow towards ventral side; fins dark spotted or having dark bands; base of all fins dark; a single prominent yellow longitudinal band running along the entire flank.

Location: Panchkula (Nada Sahib).

CONCLUSIONS

The extensive ichthyological survey conducted during the period July 2005 to June 2006 has revealed that the different waterbodies of present day Haryana state support sixty five fish species belonging to nine orders. The fish fauna of this state is a mixture of fishes inhabiting the waters having fast current, slow current, having deficient oxygen and high oxygen levels. Further, the fish diversity also include good number of riverine and hillstream fishes. From these observation, it is concluded that the Haryana state has varied aquatic ecological conditions.

As this state touches the borders of Himachal Pradesh, Punjab and Uttarakhand, the ichthyofaunal composition has great similarities with the ichthyofauna of the neighbouring states.

To identify the fish species, morphometric and meristic characters have been employed as per the definitions given by Jayaram (2010). For the easy identification of the fish species described in this monograph, field keys at appropriate levels have been developed and actual coloured photographs of the fresh fish specimens have been included so that even lay man having little interest in the fish diversity can identify the fish up to species level with great ease.

It is opined that due to urbanization, rapid pollution of most of the aquatic bodies in the state, modern agricultural practices and various water management practices, the fish fauna of this state show significant changes, when compared with the past similar reports. This time scale change in fish diversity is clear indication of change in water quality. If number and population of fishes inhabiting the oxygen deficient water bodies increase, there is degradation in the water quality. On the other hand, if the number of species and populations of minnows, Indian major carps and minor carps shows upward trend, it can be concluded that the water quality has improved.

It is suggested that in order to evaluate the loss or gain of fish diversity, both qualitatively and quantitatively inhabiting the freshwater bodies of Haryana state, periodic ichthyofaunal surveys must be undertaken.

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