

4. Genetic Resources

Genetic resource of living organisms constitutes the “first resource” of natural resources in this planet. It includes populations, gene pools, races of species, which possess important attributes not found uniformly throughout the species, breeding lines, and research materials such as mutant, genetic or chromosomal stocks. Genetic resource can also be genes themselves, maintained in selected individuals or cloned and maintained in plasmids.

Crops

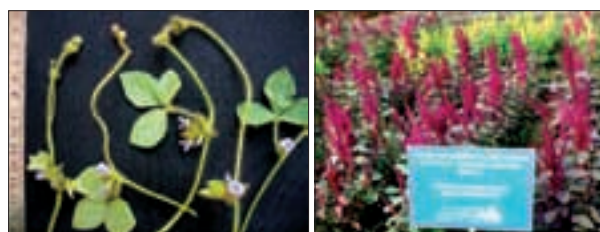
Germplasm augmentation, conservation and utilization: Twenty-nine explorations were undertaken in eight states and 1,454 accessions including 500 of wild species were collected. Three hundred eighty-three herbarium specimens were added to the National Herbarium of Cultivated Plants. In the National Gene Bank, 7,668 germplasm accessions of orthodox seed species were stored; shoot tips/meristems (48) of different vegetatively propagated species were cryostored, and 11 accessions were added to *in-vitro* storage for long-term storage. From 45 countries, 32,552 accessions were imported including international trial materials (81,969 accessions). Promising introductions included genetic stocks with heat tolerance (EC 836759), resistance to diseases and drought (EC 841516) from the USA and core sets (EC 831784-93) from Mexico of **wheat**; near isogenic lines with leaf rust resistant genes *Lr34*, *Lr46*, *Lr67*, *Lr68* (EC 841152-65) from Mexico of **barley**; tolerance to insect, drought and lodging (EC 852391-435) from the USA, bacterial leaf blight and blast resistance (EC 830646-897) from Indonesia, submergence and drought tolerance (EC 839761-5) from Philippines, high Zn content (EC 837459-585), lodging, shattering and drought tolerance (EC 846750-861) from China of **paddy**; and **tomato** and transgenic stress -tolerant **soybean** (EC 859310-11) from the USA.

Characterization and evaluation of 29,006 accessions, including wheat for terminal heat tolerance and rice for tolerance to submergence and salt, were done. Phytochemical characterization enabled identification of promising genotypes — amaranth IC 082625 with high Fe (14.6 mg/100g); buckwheat IC 026598 with high K (594 mg/100 g); faba-bean EC 243764 and adzuki-bean IC 108854 with high protein (29.3% and 23.8%, respectively) and chenopodium IC 415493 and NC 058233 with high Fe (14.7 mg/100g) and K (7.9 mg/100g), respectively.

Germplasm registration: Thirty-six novel germplasm lines were registered, including cereals for resistance to leaf and neck blast, high antioxidant activity, immunity to yellow rust, open florets for exceptionally



Horsegram diversity in seed colour



Calapo (*Calopogonium mucunoides*) Germplasm of grain-amaranth an introduced cover-crop of peninsular region

long-time, high gluten index, heat tolerance and rust resistance (9); grain-legumes for tolerance against aluminium toxicity under low pH (1); vegetables with triple pods at every node, resistance to downy mildew, powdery mildew and rust (3); fruits with low moisture-stress tolerance, bold -seeded with high 100-seed weight, irregular seed shape, large fruit size, highest number of seeds/fruit and field tolerance to papaya ring spot virus with yellow pulp colour (4); oilseeds with wilt resistance, early and non-spiny, extra early maturity, male line and lipoxygenase - 2 free with early maturity (3); fibres with narrow leaf lobe and brown lint, high ginning out-turn, distinct yellow top leaves and narrow leaf lobe with spotted petals and brown lint (5); forages with shoot-fly resistance, high digestibility with low lignin and brown midrib, black seeded with penta-foliolate leaves (3); ornamentals with double- flower shape of medium (>8 cm flower diameter) to standard size (>10 cm flower diameter), white and yellow-orange flower colour, petaloid sterile flowers multiplying through cuttings (3); and sugarcane with regular flowers (5.5% pollen fertility) to be used as female parent in introgression, regular flowers with good seed-setting, high juice quality under waterlogging and high early sugar accumulation (5).



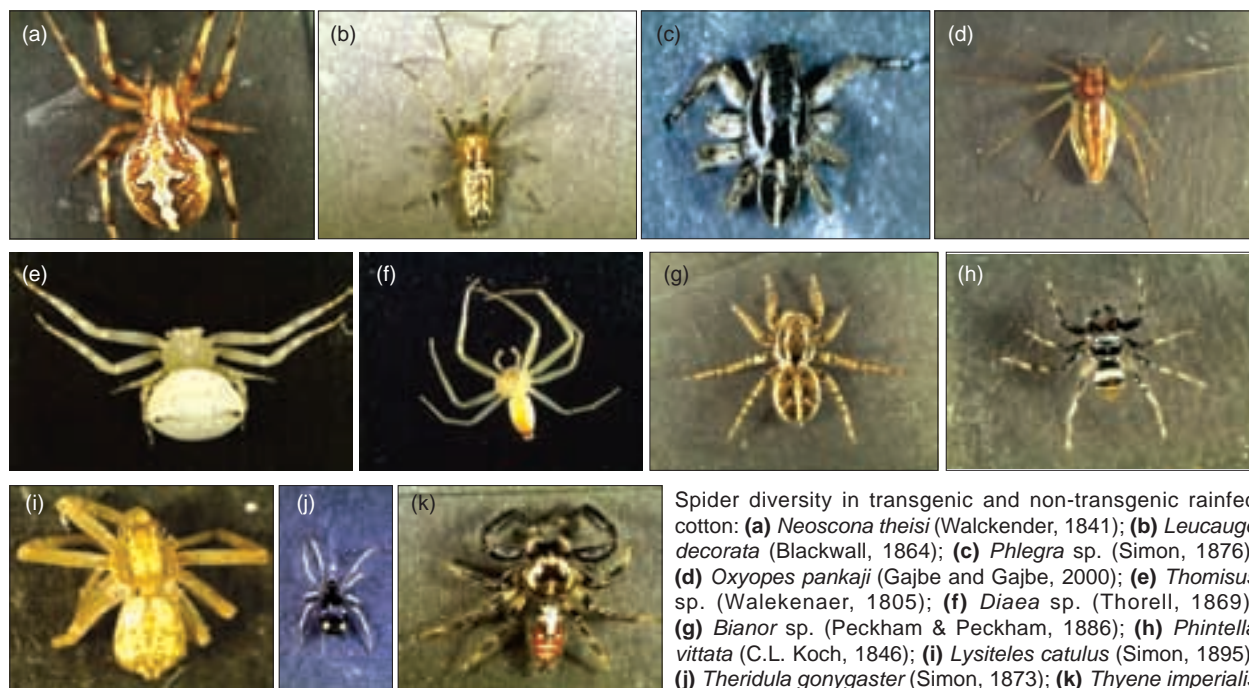
Novel genetic stocks registered

Crop	National identity	INGR No	Novel unique features
Rice	IC 0611701	15001	Resistant to leaf and neck blast
Rice	IC 0611702	15002	Resistant to leaf and neck blast
Barley	EC 0532635	15003	High antioxidant activity
Barley	IC 0612434	15004	Immune to yellow rust (<i>Puccinia striiformis</i> f. sp. <i>hordei</i>)
Cotton	IC 0613959	15005	Narrow leaf lobed and brown lint
Sorghum	IC 0611700	15006	Shoot-fly resistance
Castor	IC 0611596	15007	Wilt resistance. Early maturity. Male line
Castor	IC 0612166	15008	Non-spiny-extra-early maturity
Garden-pea	IC 0610501	15009	Triple pods at every node
Lentil	IC 0595543	15010	Tolerance against aluminium toxicity under low pH
Ber	IC 0598427	15011	Low moisture stress tolerance
Makhana	IC 0610821	15012	Large seeded (Seed diameter: 14mm). Highest 100-seed weight of 141g
Makhana	IC 0610822	15013	For irregular seed shape (mutant). Large fruit size (fruit diameter: 8.1 cm). Highest number of seeds/fruit (139)
Rice	IC 0613963	15014	For open florets. Florets remain sufficiently open for exceptionally long time. The anthers are considerably protruded outside spikelet and stigma is well exposed
Cotton	IC 0611336	15015	High ginning out-turn
Cotton	IC 0613964	15016	Distinct yellow top leaves
Soybean	IC 0612435	15017	Lipoxygenase-2 free with early maturity (85 days)
Gerbera	IC 0613966	15018	Double flower shape. Medium size (~8 cm flower diameter). White flower (RHS 155D)
Gerbera	IC 0613967	15019	Double flower shape. Standard size (>10 cm flower diameter). Yellow-orange flower (RHS 16C)
Wheat	IC 0610417	15020	High gluten index (86%)
Wheat	IC 036761A	15021	Heat tolerant
Wheat	IC 0536140	15022	Rust resistance with 3 minor/APR genes — <i>Lr34/Sr57/Yr18/Pm38</i> ; <i>Lr46/Sr?/Yr29/Pm39</i> and <i>Lr67/Sr55/Yr46/Pm46</i>
Wheat	EC 0573562	15023	Rust resistance with 3 minor/APR genes — <i>Lr34/Sr57/Yr18/Pm38</i> ; <i>Lr46/Sr?/Yr29/Pm39</i> and <i>Lr67/Sr55/Yr46/Pm46</i>
Cotton	IC 0613960	15024	Narrow leaf lobed, spotted petals and brown linted
Cotton	IC 0613961	15025	Narrow leaf lobed, spotless petals and brown linted
Berseem	IC 0613360	15026	Black-seeded with pentafoolate leaves
Sorghum	IC 0612063	15027	High digestibility (IVOMD%), low lignin content; brown midrib (bmr)
Garden-pea	IC 0598281	15028	Resistant to downy mildew and rust
Garden-pea	IC 0598280	15029	Resistant to powdery mildew
Papaya	IC 0611690	15030	Field tolerance to papaya ring spot virus with yellow pulp colour
Sugarcane	IC 0612055	15031	Good seed-setting
Sugarcane	IC 0612056	15032	Regular flower bearer with pollen fertility of 5.5%; to be used as a female parent in introgression
Sugarcane	IC 0612058	15033	Regular flower bearer with good seed-set (128 seedlings)
Sugarcane	IC 0612060	15034	High early sugar accumulation
Sugarcane	IC 0612061	15035	High juice quality under waterlogged condition
Marigold	IC 0613361	15036	Petaloid sterile flowers; multiplies through cuttings

Agriculturally important arthropods

Spider diversity in rainfed cotton: Fifteen species of spiders belong to six families — Araneidae, Oxyopidae, Thomisidae, Salticidae, Tetragnathidae and Theridiidae.

Family Araneidae contributed to one-third spider population (34.6%), followed by Oxyopidae (27%) and Thomisidae (24.5%). Frequent occurrence of *Neoscona theisi*, followed by *Oxyopes pankaji* and *Thomisus*



Spider diversity in transgenic and non-transgenic rainfed cotton: (a) *Neoscona theisi* (Walckender, 1841); (b) *Leucauge decorata* (Blackwall, 1864); (c) *Phlegra* sp. (Simon, 1876); (d) *Oxyopes pankaji* (Gajbe and Gajbe, 2000); (e) *Thomisus* sp. (Walekenaeer, 1805); (f) *Diaea* sp. (Thorell, 1869); (g) *Bianor* sp. (Peckham & Peckham, 1886); (h) *Phintella vittata* (C.L. Koch, 1846); (i) *Lysiteles catulus* (Simon, 1895); (j) *Theridula gonygaster* (Simon, 1873); (k) *Thyene imperialis* (Rossi, 1846)

spectabilis was recorded. Maximum population of spiders was observed during second fortnight of October to first fortnight of November, coinciding with boll-development stage. Positive correlation of spiders with prey density of cotton-sucking pests was observed in the case of whitefly and mirid while it was negatively correlated with aphids, leafhoppers and thrips. No noticeable effect of either genotype-based variation (transgenic or non-transgenic) or limited pesticide intervention was observed on spider population. These observations indicate a potential for their utilization in biological control of whitefly and mirid bugs.

Horticulture

A total of 1,503 indigenous collections comprising fruits, vegetables, tuber crops, plantation crops and nuts, spices, medicinal and aromatic plants, ornamental crops and mushrooms were made from different states.

Fruit crops: Sixteen exotic grape accessions were received from the United States Department of Agriculture, of which six were successfully established in field gene bank. Pomegranate accessions (132) were collected from the Michigan State University, of which 120 regenerated and successfully established in field for further evaluation. Datepalm saplings (41) comprising three different germplasm accessions (MIMI, MHNB and MRKS) were introduced from ICARDA, Amman, Jordan, and established in field gene bank at Bikaner. Exotic cocoa germplasm accessions (22) including white bean types rich in flavour components were introduced through International Cocoa Quarantine Centre, University of Reading, United Kingdom. A total of 13 exotic germplasm of *Phaseolus* spp., comprising *Phaseolus lunatus* (9), *P. coccineus* (2), *P. acutifolius* (1) and *P. vulgaris* (1) were introduced at Varanasi from the Asian Vegetable Research Center, the World Vegetable Centre, Taiwan.

Benaolini, a cocunut land rave of Gra, was identified. It has tender cocunut water traits and copra.

A total of 33 mango varieties from Custodian Farmers were identified from Malihabad and adjoining areas of Lucknow, Uttar Pradesh and multiplied for on-farm and *in-situ* conservation. Of the 152 accessions screened, Lazzat Baksh, Kishen Bhog, Guruvam and Starch showed least susceptibility (< 1/panicle) to hopper, *Idioscopus* spp. The species diversity of mango hoppers across the mango accessions was > 90% of *Idioscopus niveosparsus*, 7% of *Idioscopus nagpuriensis* and rest others.

Of the 50 accessions of jackfruit evaluated for infestation of shoot- and fruit-borer, *Diaphania caesalis*, accessions, G-1, G-2, G-9 and G-65, were free from infestation. A potential chance seedling, CIAH-Ber-S-15, of ber with semi-erect growth, 18% pulp TSS and 0.47% acidity was identified for late maturity (mid to late February). A promising aonla clone, CISH-A-33, was identified most promising for yield (55.45 kg/tree) and nutraceuticals (ascorbic acid, 490 mg/100g fruit; polyphenol, 1.718 TAE g/100 g). Similarly, another accession, CISH-A-35, was found promising for nutraceuticals (gallic acid-7.05 mg/g; caffeic acid-301 mg/g).

Of the 36 bael accessions evaluated, CISH-B-18 was found high-yielding (73.32 kg/tree) with medium-sized fruits (1.88 kg), high TSS (42.4°Brix), high total sugar (22.53%), total carotenoids (3.79mg/100g) and tannins (3.79%). Of the 1,000 pomegranate 'Daru' progenies evaluated, six were found free from bacterial blight, while 14 showed tolerance ($\leq 5\%$ blight) to bacterial blight.

Of the 91 germplasm accessions of walnut evaluated, four accessions with higher nut and kernel weight, viz, CITH W-1 (29.05g and 14.09g), CITH W-6 (24.35g and 13.64g), CITH W-9 (23.77g and 12.02g) and CITH W-8 (23.1g and 11.08g) were observed promising for further evaluation. Of these, CITH W-1 had 53.11% kernel



recovery. Similarly, of the 23 germplasm accessions of almond evaluated, CITH A-8 (50%), CITH A-21 (48.38%) and CITH A-23 (45.85%) were found promising for higher kernel recovery. CITH A-8 being soft-shelled and others semi-hard shelled.

A promising rose apple clone, CHRA-1, with 35.4 g fruit weight, 14.5 kg/plant fruit yield, 13.8% TSS, 84.5% pulp and fruit maturity during March-May was identified for east coast region. A promising star gooseberry clone, CHSG-1, with 3.8 g fruit weight, 900-950 fruits/plant, 3.8 kg/plant fruit yield, 7% TSS, 92% edible portion and 90-100 mg ascorbic acid/100g pulp was identified promising for east coast region. A promising carambola clone, CHCM-4, with 95-100g fruit weight, 170-180 fruits/tree (14-15kg), 11% TSS, 90 - 92% edible portion was identified promising for east coast region.

Vegetable crops: Nine exotic collections of watermelon and four each of ridge gourd and sponge gourd were introduced from the USDA, ARS, Griffin, Georgia, USA at Bikaner. An accession, VRPG-89, of pointed gourd was identified for low seed (4-8 seeds/fruit) content. Chilli genotypes, BS-20 and BS-79, were identified for tolerance to leaf curl under field condition. A Dolichos yellow mosaic virus tolerant accession of Indian bean (VRSEM 12) was identified. A unique onion genetic stock (DOGR-1203-DR) with extra early maturity (90 days after planting) and uniform neck fall in *rabi* was registered (IC0598327, INGR14057) with NBPGR, New Delhi.

Spices: A total of 243 accessions of black pepper including 158 cultivars and 85 accessions of related taxa were collected. An accession of *Piper barberi*, considered an endangered species, was located in the evergreen

forests of Anakulam forest range of Kerala.




Farmers' participatory germplasm collection of spices: In a farmers' participatory germplasm collection, 31 nutmeg (*Myristica fragrans*) types including farmers' varieties and unique germplasm were collected and conserved. This includes rudimentary sterile seed; bold nut; thick and entire mace; high-yielding monoecious types. Punnathanam Jaythi, a farmers' variety of nutmeg, with very bold nut and thick mace was collected. In addition, three unique high-yielding black pepper, 10 bold and one unique black ginger (*Kaempferia parviflora*) and three unique clove (dwarf clove, king clove and extra bold Madagascar clove) were collected and added to the field gene bank.

An accession of turmeric (Acc. 849) was identified promising for high yield (42.5 tonnes fresh corm/ha). Long pepper (*Piper longum*) germplasm accessions, viz. JPL-12 (7.85%), JPL-6 (7.64%), JPL-17(7.66%), JPL-3 (5.46%) and JPL-19 (5.24%) with higher piperine than Viswam (5.15%) were identified.

Livestock

Registration of new breeds: Seven new breeds of indigenous livestock (two breeds of cattle, one breed each of goat, sheep, pig, camel) and one line of chicken were registered during 2015. Presently, the total number of registered indigenous breeds in the country is 151 (39 cattle; 13 buffalo; 24 goat; 40 sheep; 6 horses and ponies; 9 camel; 3 pig; 1 donkey; and 16 chicken). One chicken line - PD1 (Vanaraja male line) developed by ICAR-DPR, Hyderabad has been registered for the first time in the country.

Newly registered breeds

Breed	Home tract	Accession number/Description	Photograph
Belahi cattle	Haryana and Chandigarh	INDIA_CATTLE_0532_BELAHI_03038 Belahi is a dual type cattle reared for milk and draught by Gujjar community in foothills of Haryana. It is reared under low input migratory system. Belahi produces about 3.25 kg milk/day.	
Gangatiri cattle	Uttar Pradesh and Bihar	INDIA_CATTLE_2003_GANGATIRI_03039 Gangatiri , a dual purpose cattle breed, is found in Eastern Uttar Pradesh and Western Bihar along the river Ganga. These cattle are well adapted to low to medium input production system and produce about 2.5 to 8.0 kg milk/day.	
Pantja goat	Uttarakhand and Uttar Pradesh	INDIA_GOAT_2420_PANTJA_06024 Pantja goats are reared for meat and milk in Udham Singh and Nainital districts of Uttarakhand and adjacent <i>Tarai</i> area of Uttar Pradesh. These goats are well adapted to humid condition of <i>Tarai</i> . Twining is common in Pantja goats.	



Breed	Home tract	Accession number/Description	Photograph
Kachaikatty Black sheep	Tamil Nadu	INDIA_SHEEP_1800_KACHAIKATTY BLACK_ 14040 Kachaikatty Black sheep are maintained as small flocks in Vedipattitaluka of Madurai, Tamil Nadu. Animals are of medium size, compact body and black with hairy coat. The breed is reared for meat and manure. Rams are well known for fighting.	
Kharai camel	Gujarat	INDIA_CAMEL_0400_CAMEL_02009 Kharai camel is found in coastal part of Kachchh, Gujarat. These camels are well adapted to both dry-land as well as costal ecosystems. These have excellent swimming capacity in sea water and graze mainly on mangrove and other saline species. Kharai camels can thrive on high saline water and tolerate high total dissolved solids.	
Agonda Goan pig	Goa	INDIA_PIG_3500_AGONDA GOAN_09003 Agonda Goan are small size local pigs of Goa. These pigs are mostly black with short snout. Bristles are rough. People prefer these animals for sausage making. It is well adapted to local coastal environment.	
Mewari chicken	Rajasthan	INDIA_CHICKEN_1700_MEWARI_12016 Mewari chicken is found in Central and Southern parts of Rajasthan; reared for egg and meat under free range or scavenging system. Adult cocks weigh about 1.9 kg and hens 1.2 kg. Annual egg production ranges from 37 to 52. Egg weight is about 53g.	
PD1 (Vanraja male line)	Andhra Pradesh	INDIA_CHICKEN_001_PD1_13001 PD1, the first registered line of chicken in India, was developed by ICAR-Directorate of Poultry Research, Hyderabad for higher shank length and is used as male parent for Vanraja commercial, a dual purpose backyard poultry. Average adult body weights of males and females ranges from 3.5 – 4.0 kg and 2.5 – 3.0 kg. Egg production is about 85 up to 52 weeks of age.	

Phenotypic characterization

Siri cattle of Sikkim: The Siri cattle is brown, black with white spots and admixtures. Skin is grey, muzzle and eyelids are black and forehead is convex, wedge shaped with white patches. Ears are small and horizontally oriented, horns are small and curved outward, forward and upward. Udder is small with funnel/cylindrical shaped teats. Naval flap is absent. Tail is with black, brown and grey switch reaching up to the hock. The average body length, height at withers, heart girth, paunch girth, horn length, ear length, face length, face width, tail length without switch and with switch in cows are 106.32±1.40 cm, 114.20±1.55 cm, 157.80±2.52 cm, 162.16±2.61 cm, 16.48±0.79 cm, 18.24±0.26 cm, 40.88±0.75 cm, 20.84±0.37 cm, 75.56±2.29 cm and 95.56±6.59 cm, respectively. The age at first calving,

lactation length and calving interval ranges from 40-60 months, 200-240 days, 450 to 600 days, respectively. The daily milk yield ranges from 2.0 to 6.50 kg.

Kajali sheep of Punjab: Kajali, a mutton type sheep, is distributed in Sangrur, Barnala, Ludhiana, Moga and adjoining districts of Punjab. The average body weights of adult males and females are 56.98 ± 1.02 and 43.23 ± 0.36 kg, respectively. The overall means for body length, height, chest girth, ear length and tail length are 73.97± 0.28, 73.36 ± 0.20, 84.23 ± 0.27, 21.33 ± 0.08 and 55.83± 0.37 cm, respectively. Kajali sheep has colour variants: Black (Kali) and White (Chitti). The animals are large with well-built body, having roman nose, long and pendulous ears and long tail touching ground. Both sexes are generally polled. Average greasy wool production is 800 to 1,000 g.



Singharey goat of Sikkim: Singharey goats constitute the major part of the goat population of Sikkim. They can be distinguished from other populations by the facial stripes. The ears are short to medium semi pendulous with round tip. The ears have black or white margin on the apical half. The horns are strong, flat, thicker at the base but pointed at the tip, orienting upward and backward. Legs are short, stout, medially black or white. Black top line was seen in many of these goats. Height at withers, body length, chest girth, paunch girth, face length, horn length, ear length and tail length



(cm) of adult females are 52.52 ± 0.71 , 60.29 ± 0.66 , 67.98 ± 0.59 , 74.52 ± 1.25 , 16.16 ± 0.19 , 8.84 ± 0.33 , 13.48 ± 0.18 and 10.88 ± 0.24 , respectively, and of males 55.67 ± 0.93 , 61.48 ± 0.86 , 71.66 ± 0.85 , 76.47 ± 1.16 , 17.20 ± 0.22 , 14.58 ± 0.57 , 12.92 ± 0.24 and 11.89 ± 0.25 , respectively. The average body weight in females is 27.33 ± 0.65 kg and in males 31.03 ± 0.92 kg.

Molecular characterization

Laddakhi cattle: Microsatellite based genotypic data were generated using 20 markers. A total of 200 alleles were detected with mean number of 9.95 alleles/locus. The within breed diversity measures in terms of observed number of alleles (9.95), effective number of alleles (4.84), observed heterozygosity (0.75) and expected heterozygosity (0.79) for Ladakhi cattle revealed sufficient genetic variability. The values were significantly different from zero. The average inbreeding

coefficient (F_{IS}) in Ladakhi cattle was 0.037. The interbreed differentiation between Ladakhi and other cattle populations depicted by F_{ST} reflected high genetic divergence between different cattle breeds.

Breed signature for cattle: The data on 541 farm individuals from 3 breeds (Gir, Sahiwal and Tharparkar) using 4 STR loci were generated and analysed to develop breed signature. F_{ST} values were 0.173, 0.281 and 0.235 between Gir and Sahiwal, Gir and Tharparkar and Sahiwal and Tharparkar, respectively. Selection of loci was attempted and finally eight loci were able to assign 100% individuals belonging to the farms of these three breeds and 93% when added the field samples. All the individuals from organized farms were found to be correctly assigned and 3 breeds formed different clusters. These loci were used to develop a multiplex PCR kit. The kit was tested and validated to be used for Sahiwal, Gir and Tharparkar cattle breed assignment.

Ex-situ conservation

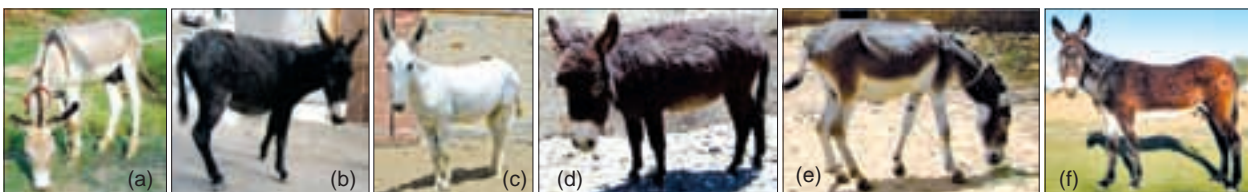
Total 7,600 frozen semen doses of cattle (Gaolao and Tharparkar) and buffalo (Toda) were added to repository in Gene Bank during the year. Jaffarabadi buffalo semen stored in Gene Bank was also utilized in its breeding tract for supporting conservation and improvement. The National Gene Bank at NBAGR now stores 129,174 frozen semen doses belonging to 44 breeds of cattle, buffalo, goat, sheep, camel, equine and yak.

To utilize caprine cauda epididymal spermatozoa for cryopreservation, an extender was standardized for freezing epididymal semen. The storage of testes at low temperature indicated suitability of utilizing them for extraction of epididymal sperms for their conservation, even after extended hours post slaughtering of bucks. *In vitro* fertilization revealed that frozen epididymal spermatozoa retained the fertilizability.

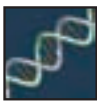
Cattle

Screening of Frieswal bulls and bull calves for genetic diseases: Frieswal bull calves (151) were screened against bovine leukocyte adhesion deficiency (BLAD), deficiency of uridine monophosphate synthase (DUMPS), and bovine citrullinaemia. A carrier prevalence percentage of 4.6 was noticed for BLAD in Frieswal bull calves, while no carriers were noticed for other genetic disorders studied.

Genetic studies in donkey population: Donkey germplasm of six donkey populations belonging to Spiti (Himachal Pradesh), Leh (Jammu and Kashmir), Baramati (Maharashtra), Bihar, Gujarat and Rajasthan areas along with exotic Poitu breed (an outgroup) were



Donkeys from—(a) Bihar, (b) Jammu & Kashmir, (c) Gujarat, (d) Himachal Pradesh, (e) Rajasthan and (f) Exotic (Poitu)



evaluated for assessing genetic diversity within and between them using 24 polymorphic microsatellite markers with 299 donkey DNA samples. The estimates of F_{ST} between each pair of breeds revealed that genetic differentiation between donkey population from Gujarat and Leh were the maximum followed by Rajasthan and Leh donkey populations while donkey populations from Rajasthan and Spiti (Himachal Pradesh) areas were the least differentiated. On comparing all the donkey populations, donkeys from Spiti and Rajasthan were very close to each other, whereas donkeys from Leh (Jammu and Kashmir) and Gujarat areas were far apart.

Camel: Partial amplification of TLR5 gene (1136 kb) and TLR1 gene (930 bp) of *Camelus dromedarius* was achieved and cloned. Eight 5' flanking regions/exons/mRNA of milk protein genes were successfully amplified in dromedary and amplified fragments were characterized by RFLP using suitable restriction enzymes. Uniqueness of the five sequences was established.

Identification of male specific genes of yak: The male subfertility in yak population is a major issue, which causes huge economic losses to yak farmers. Mammalian Y chromosomes tend to acquire sequences which are necessary for spermatogenesis and male reproduction. The critical Y-linked fertility genes are present in multiple copies with testis-limited expression. To understand this novel complexity, 12 MSY genes i.e. *SRY*, *TSPY*, *TSPY4*, *TSPY6P*, *FAM197Y1*, *USP9Y*, *UTY*, *DDX3Y*, *AMELY*, *TXLNG2P*, *HSFY1* and *HSF2Y* were identified and their expression pattern was established in yak genome.

Standardization of chicken sperm transfection

Transfected sperm are the pre-requisite for sperm mediated gene transfer. The procedure for transfecting the chicken (broiler breeder) sperm using lentivector with GFP gene was standardized. The sperm up to two washes were adjudged to be suitable for fertilization of eggs and were subjected to incubation with GFP lentivector while a negative control was also kept. After incubation, exogenous vector which was not internalized was removed. Thereafter, RNA was collected from sperm cells. The cDNA was prepared and used as template in PCR reaction with eGFP genes specific primers. The amplified PCR product for eGFP was detected in 1.5% agarose gel. A band of 137 bp in sperm samples confirmed transfection.

Mitochondrial genotyping of mithun: Phylogenetic analysis of mitochondrial genotyping of mithun, on the basis of Cytochrome B gene, revealed the placement of mithun in the same clade with gaur. The mithuns from different geographical locations (Nagaland, Arunachal Pradesh, Manipur, and Mizoram) showed a close relationship (0.929) among themselves, but were found distantly related to cattle (0.879) and yak (0.879).

In first ever study of fluorescent *in-situ* hybridization (FISH) of mithun chromosomes, highly repetitive regions of centromere and telomere were amplified using bovine primers. The centromeric signals were observed in all the acrocentric autosomes of all the species. However,

in contrast to Tho-Tho cattle, FISH signals could not be detected in the sub-metacentric chromosomes of mithun, mithun – cattle crossbreds and gaurs.

The results of mitochondrial genotyping and FISH confirmed a more ancestral closeness of mithun with gaur than that with cattle.

Genomic profiles of chicken lines: The whole mitochondrial genome sequence of seven Indian native chickens, namely Aseel, Ghagus, Nicobari (Black and Brown), Tellicherry, Kadaknath, Haringhata Black and Red Jungle fowl was explored. All indigenous breeds, except Tellicherry were very close together and close to the lineage of Red Jungle fowl. Polymorphism in BMP3 and BMP4 genes in chicken was explored. This gene was also polymorphic in control layer (CL) line having 4 haplotypes. The BMP4 gene was polymorphic with presence of 4 haplotypes. The haplogroups of both genes had significant association with juvenile body wt. Protocol for gene silencing using shRNA molecules for myostatin gene in chicken was perfected.

Native chicken populations: Four native chicken populations, PD-4 (Improved Aseel), Aseel, Ghagus and Nicobari fowl were conserved at the ICAR-DPR, Hyderabad. The survivors' egg production up to 72 weeks of age was 156.5 ± 2.79 eggs in PD-4 birds in S-4 generation. Body weight at 8 and 16 weeks of age was improved by 33 and 126 g, respectively. The egg production up to 64 weeks of age in native Aseel chickens, brought from home tract in Andhra Pradesh was 43.76 eggs during the first generation. The age at sexual maturity (ASM) was 215 d. In G-2 generation of Ghagus, ASM, egg production up to 40 weeks and egg weight at 40 weeks of age were $169.5 \pm 0.74d$, 32.9 ± 1.24 eggs and 46.7 ± 0.48 g, respectively. In Nicobari fowl, egg production up to 40 weeks of age was 62.4 ± 1.67 and egg weight and shank length at 40 weeks of age were 43.8 ± 0.43 g and 80.0 ± 0.65 mm, respectively.



Ghagus cock



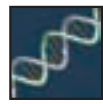
An adult pair of PD-4

Meat species identification: A proteomic based approach using OFFGEL fractionation and tandem mass spectrometry (LC-MS/MS) was developed, which can efficiently detect 1.0% contaminating buffalo meat mixed with sheep meat in both raw and cooked samples. The polymerase chain reaction-restricted fragment length polymorphism (PCR-RFLP) based molecular technique was efficient in detecting 0.5% of beef mixed with buffalo meat.

Fish

Fish biodiversity in rivers: Exploratory surveys were carried out in the Western Ghats, the North Eastern Region and central India.





Freshwater fish species (67) including four exotic species were recorded in Sharavathi river basin. Specimen of lesser known catfish *Batasio sharavatiensis*, miniature gobiid *Redigobius bikolanus* and *Schismatogobius deraniyagalai*, and minnows *Laubuka laubuka* are the new records from this river basin. Finfish (39) and crustaceans (6) species were recorded from Valapattanam river basin. *Mesonoemachilus guentheri*, *Pethia pookodensis* and *Pseudogobiopsis oligactis* are the new records from this river system. Chaliyar and Chandragiri river basins yielded 25 and 35 finfish species, respectively, while Chandragiri river basin also yielded six crustacean species.

*Batasio sharavatiensis**Redigobius bikolanus**Schismatogobius deraniyagalai*

In upper Mahanadi river basin 23 sites and its six tributaries and sub-tributaries namely, Sheonath, Mand, Hasdeo, Maniyari, Arpa and Lilagar were explored and 82 fish species were recorded. Along the 650 km stretch of river Mahanadi from Seorinarayan to Bahakuda Ghat, 144 fish species were recorded indicating dominance of Cyprinids.

In Torsha and Gandak rivers of the Ganga-Brahmaputra basin, surveys conducted in 100 km stretch of Torsa river from Madarihaat, Maltiguri (Cooch Behar, West Bengal) and Balarampur, recorded 16 small indigenous fish species. *Aspidoparia morar*, *Barilius* sp., *Puntius* sp., *Cirrhinus reba* and *Salmophasia* sp. were dominant. *Tor putitora* and *Cyprinion semiplotum*, the endangered species in IUCN list, were also recorded from the river stretch.

In Gandak river along Hajipur, Muzaffarpur and Bettiah stretches, *Aspidoparia morar* (63%), *Ailia coila* (3%), *Mystus vittatus* (6%), *Puntius conchoniis* (6%), *Gagata cenia* (6%), *Botia lohachata* (4%), *Securicula gora* (2%), *Crossocheilus latius latius* (8%) and *Sicamugil cascasia* (2%) were recorded. Among them *Ailia coila*, *Nangra nangra*, *Puntius conchoniis*, *Sicamugil cascasia* and *Botia lohachata*, *Eutropiichthys vacha*, *Ompok pabda* are in the list of vulnerable and endangered category, respectively.

Mitogenome of fishes: Complete mitochondrial genome of brown trout (*Salmo trutta fario*) was sequenced. A phylogenetic analysis among 42 complete mitogenomes of family Salmonidae and one sequence of *Danio rerio* depicted the position of species among genus *Salmo*.

The complete mitochondrial genome of endangered deccan mahseer, *Tor khudree* is 16,573 bp in size, and

consists of 13 protein coding genes, 22 tRNAs, 2 rRNA genes and one control region. The overall base composition is - A: 31.9%, G: 15.6%, C: 27.68%, T: 24.76%; A+T content 56.6%; and G+C content 43.32%.

Complete nucleotide sequence of mitochondrial genome of Indian oil sardine, *Sardinella longiceps* is a 16613 bp circle, containing 37 mitochondrial structural genes (two ribosomal RNA, 22 transfer RNA, and 13 protein-coding genes).

Genetic characterization of Spanish mackerel: The population genetic structure of the commercially important fish, narrow barred Spanish mackerel, *Scomberomorus commerson* along Indian coast

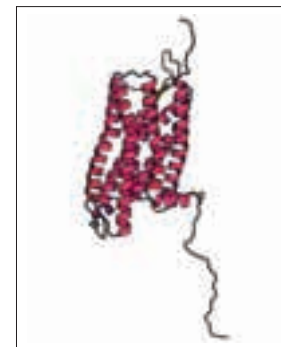
*Scomberomorus commerson*

(Mangalore, Cochin and Veraval in the west coast; Chennai and Vishakhapatnam in the east coast), was analysed. Pair wise co-efficient of genetic differentiation (F_{ST}) values did not exhibit any significant difference between the populations of *S. commerson* indicating that the species can be considered as a unit stock for fishery management in Indian waters.

Stock characterization in Indian shad: Distribution of Indian shad (*Tenualosa ilisha*) in freshwater habitat extends through the rivers Hooghly, Brahmaputra, Ganga, Godavari, Mahanadi, Narmada and Tapti while in marine habitats it is found in Arabian Sea and Bay of Bengal.

Mitochondrial cytochrome b F_{ST} value of 0.58807 indicated significant genetic divergence between east and west coast samples and phylogeny into two distinct clades with a common origin. Freshwater samples from Ganga, Brahmaputra and Padma showed population sub-structuring, however, discriminant analysis on the basis of morpho-metric traits indicated existence of a single stock. Marine samples from Digha (West Bengal) and Kirtinia (Odisha) were genetically distinct from that of Barrackpore area and Godhakali (Hooghly river) but not from Brahmaputra and Ganga.

Kisspeptin-1 (*kiss1*) gene and its receptor: Kisspeptin-1 (*kiss1*) and kisspeptin-1receptor (*kiss1r*), important regulators of reproduction, were isolated, cloned and characterized from brain tissue of Himalayan golden mahseer, *Tor putitora*. The structure modelling of *Kiss1r* showed strong conservation of tertiary structure with other vertebrates. Structural analysis of *kiss1r* pre-protein was carried out to evaluate the degree of conservation in tertiary structure during the course of evolution.

Tertiary structure of golden mahseer *Kiss1r*

**Whole genome analysis of *Halomonas salina***

CIFRI1: An extreme salt stress tolerant bacterium *Halomonas salina* Strain CIFRI1 was isolated from salt crystals in salt pans of Digha, West Bengal. The draft genome of *Halomonas salina* had 3,450,272 bases with 3,139 protein-coding loci including 62 RNA genes.

Discovery of new fish species *Clarias serratobranchium* sp. nov.: A new fish species *Clarias serratobranchium* sp. nov. was discovered from the wetlands near Moreh, Manipur in the Chindwin basin, along Indo-Burma border. The diagnostic characters include separation of median fin from caudal fin; anal-fin with 66–68 rays; anterior fontanel short and squat, anterior tip reaching to line through two-thirds of orbits;



Clarias serratobranchium, a new species of south East Asian walking cat fish

pectoral spine serrated anteriorly as well as posteriorly. DNA barcoding of the individuals further supported the morphological and osteological features of *C. serratobranchium* sp. nov. The phylogentic analysis (maximum likelihood) of nine species of genus *Clarias* clearly differentiates the new species.

