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Phenotypic characterization and documentation of animal genetic resources in India: A review

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ABSTRACT

Phenotypic characterization is essential for planning and managing the animal genetic resources at local, national, regional and global levels. Large proportion of non-descript animals of different livestock species indicated that the characterization and inventorization of animal genetic resources of India is still incomplete. After establishment of National Bureau of Animal Genetic Resources (NBAGR) at Karnal by Indian Council of Agricultural Research (ICAR), phenotypic characterization of domestic animal diversity of India, accelerated. A large number of recognized livestock and poultry breeds and populations were systematically studied and documented in last three decades. A system of registration of livestock and poultry breeds was initiated by ICAR in India in 2008 with the registration of 129 livestock and poultry breeds. Thirty one new breeds were registered from 2010 to 2016. With the introduction these newly registered breeds, total number of indigenous breeds in the country now stands at 160, which include 40 breeds of cattle, 13 buffalo, 26 goat, 42 sheep, 6 horse and pony, 9 camel, 6 pig, 1 donkey and 17 of chicken. After registration of breeds, the breed descriptors were published in *The Indian Journal of Animal Sciences*. A large number of breed monographs were also published by different agencies. This review provides information of the breeds or population of livestock and poultry undertaken for phenotypic characterization and documentation in India.

Key words: Animal genetic resources, Breed, Documentation, Phenotypic characterization

FAO's Global Plan of Action for Animal Genetic Resources (AnGR) recognizes that "a good understanding of breed characteristics is necessary to guide decision-making in livestock development and breeding programmes". Phenotypic characterization of AnGR for food and agriculture is the practice of systematically documenting the observed characteristics, geographical distribution, production environments and uses of these resources. The information provided by characterization studies is essential for planning the management of AnGR at local, national, regional and global levels. The Global Plan of Action's Strategic Priority Area 1 is devoted to "*Characterization, Inventory and Monitoring of Trends and Associated Risks*" FAO (2007). Therefore, it is imperative to characterize and document all available AnGR of the country. In this review paper, an attempt was made to review the work done so far in India for characterization and documentation of indigenous AnGR.

Current status of Indian livestock and poultry wealth of India

As per the last livestock census carried out by Government of India (Livestock Census 2012), a total of 512.06 million of mammalian livestock and 729.21 million poultry are available in India. In this census, 11 mammalian species (cattle, buffalo, yak, mithun, sheep, goat, horses and ponies, mule, donkey, camel and pig) and 3 avian species (fowls, ducks and turkey and others) were included. Apart from census of these species, dog, rabbit and elephant head counting was also conducted. The census indicated that more than 99.5% of total mammalian livestock is represented by 5 major species viz., cattle, buffalo, sheep, goat and pig and about 95% of total avian AnGR are represented by fowl (chicken). After the 19th livestock census, Government of India also conducted breed survey in 2013 so as to get estimated breed-wise livestock population for 7 mammalian species (cattle, buffalo, sheep, goat, horses and ponies, camel and pig).

The analysis of breed survey-2013 indicated that 5 sub-categories may be made within the species census. These sub-categories are exotic breeds, crossbreds to exotic breeds, indigenous breeds, grades to the indigenous breeds and non-descript indigenous. The proportions of animals under these sub-categories are mentioned in the Table 1.

The data (Table 1) revealed that non-descript animals are available in all these 7 species with proportion varying from 28.22% in camel to 80.43% in horses/ponies. This large proportion of non-descript animals indicated that the characterization and inventorization of AnGR of India is

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Table 1. Current status of Indian livestock and poultry wealth of India as per Breed Survey, 2013

Species	Population in thousands	Number of breeds		Proportion of different categories (in percent)				
				Indigenous animals			Exotic and crossbred	
		Exotic origin	Indian origin	Purebreds	Graded pure breeds	Non-descript	Exotic breeds	Cross breds
Cattle	190904	2	37	9.35	10.51	59.33	0.69	20.12
Buffalo	108702	0	13	17.05	39.58	43.37	0	0
Goat	135173	0	23	26.97	11.77	61.26	0	0
Sheep	65069	3	37	36.55	18.95	38.69	0.72	5.09
Pig	10294	6	02	3.03	0	73.11	2.33	21.53
Camel	400	0	06	71.78	0	28.22	0	0
Horses & Ponies	625	0	06	19.57	0	80.43	0	0

still incomplete. With the mandate of identification, characterization, evaluation, conservation and sustainable utilization of AnGR, NBAGR was established at Karnal under the aegis of ICAR, Government of India. This institute initiated the characterization and inventorization of AnGR of India at a bigger scale and in last 3 decades, many livestock and poultry populations were systematically studied, characterized and documented, which has been summarized in this paper.

Objectives of phenotypic characterization

- To identify new breed from non-descript population of species.
- To delineate the actual geographical distributions of the breed along with the study of native environments.
- To get population status of breed and socio-economic status of communities rearing the breed along with management practices.
- To document physical, morpho-metric and performance characteristics of the breed.
- To identify elite animals to be used in breed improvement programmes.
- To develop monitoring mechanism for genetic improvement and conservation or sustainable utilization of the AnGR.
- To create public awareness regarding the importance of AnGR diversity.
- To document AnGR diversity.

Constituents of phenotypic characterization

Phenotypic characterization involves systematic survey of breed to collect and analyze the information on following aspects:

- Demographical and geographical distribution of the breed/population.
- Native environment/habitat of the breed/population.
- Enumeration of breeds in terms of age and sex in a population.
- Management practices and utility of the breed/population.
- Socio-economic status of the communities rearing the breed.
- Qualitative and quantitative characterization of breeds in relation to morphological traits, production potential and reproductive status etc.
- Qualitative and quantitative description of unique animals, elite producers and rare or unusual characteristics in certain specimens.
- Images of typical adult males and females, as well as herds or flocks in their typical production environments.
- Relevant indigenous knowledge (including gender-specific knowledge) of management strategies used by communities to utilize the genetic diversity in their livestock.

Characterization of AnGR under institute research projects of NBAGR

After establishment of NBAGR, Karnal in 1984 by the ICAR, methodologies for characterization of Livestock and Poultry breeds through systematic survey were developed. NBAGR took several institute projects for characterization of breeds/non-descript populations of Indian livestock and poultry. In such projects, the scientists of NBAGR visited the native tracts of breeds to collect information on pre-designed questionnaires. Such studies included collection of information on history, geographical distribution, approximate population size, native environment, socio-economic status of livestock owners, management practices in terms of breeding, feeding, housing, sanitation, health, marketing *etc.* through interview and personal observations. Data recording on physical characteristics of the breed, morpho-metric traits, growth production and reproduction performance was taken up so as to develop the breed descriptors. The main drawback in such projects was that all the information was collected by undertaking 3–6 visits in the breeding tract. Therefore, some information like lactation milk yield, inter-calving period, body weights of same animal at different ages, accurate age at first calving, carcass traits, wool quality traits etc. could not be generated.

Therefore, Network Project on AnGR was introduced by ICAR, where data recorders and other staff were appointed temporarily in collaboration with some local agencies. In such projects, it was possible to generate all kinds of information needed for characterization and developing breed descriptors of a breed. However, the information generated under institute research projects on phenotypic characterization at NBAGR helped in understanding the diversity of domestic livestock of India. Up to now, more than 100 breeds/populations were considered for phenotypic characterization of cattle, buffalo, sheep, goat, pig, horse, camel, donkey, yak, mithun, chicken and duck species. Some of these breeds/breed populations are discussed in the next paragraph.

Cattle: Cattle (*Bos indicus* and *Bos tauras*) is the major livestock species representing 37.28% of total mammalian livestock population of India. As per livestock census conducted in 2012 and Breed survey in 2013, 9.35% of total cattle were classified as pure breeds representing 37 indigenous cattle breeds and 10.51% of total cattle were classified as grades of 37 recognized indigenous breeds. These graded animals of different breeds may be converted to their respective breeds by mating them with pure breed bulls for one or more generations. On the other hand, 20.81% of total cattle population belongs to either pure exotic breeds (0.69%) of *Bos tauras* or as crosses of *Bos tauras* and *Bos indicus* (20.12%). Rest of Indian cattle population (59.33%) has been classified as non-descript indigenous animals. These non-descript animals are found in almost all the states of India in varying proportions. Therefore, it is imperative to explore these cattle populations for identification of new cattle breeds in India. Since inception of the breed registration, 10 such cattle populations were registered as new breeds. Further, it is also important to describe the recognized cattle breeds in a systematic manner by studying these populations in their native tracts. In view of above considerations, many recognized as well as new breeds were characterized in a systematic manner so as to develop their breed descriptors. The breeds/populations of cattle characterized include Sahiwal (Tantia *et al.* 1999), Hariana (Joshi *et al.* 1995), Rathi, Tharparkar (Nivsarkar *et al.* 1992), Nagori (Vij *et al.* 1997), Ponwar (Gaur *et al.* 2004), Kherigarh (Singh *et al.* 2005), Kankrej (Pundir *et al.* 2007a), Gangatiri (Singh *et al.* 2007b), Mewati (Singh and Pundir 2007), Kenkatha (Pundir *et al.* 2007c), Red Sindhi (Pundir *et al.* 2007d), Krishna Valley (Singh *et al.* 2007c), Red Kandhari (Pundir and Singh 2008), Hallikar (Singh *et al.* 2008a), Malnad Gidda (Singh *et al.* 2008b), Bargur (Pundir *et al.* 2009), Pullikulam (Singh *et al.* 2012), Hill cattle of Uttarakhand (Pundir *et al.* 2010, 2012, 2013, 2014b), Shahabadi (Sharma *et al.* 2012a), Purnea (Sharma *et al.* 2013); Indigenous cattle of Tripura (Pundir *et al.* 2014a), Mizoram (Pundir *et al.* 2015b) and Manipur (Pundir *et al.* 2015a), Sanchori (Singh *et al.* 2015a), Siri (Pundir *et al.* 2016), Nari (Singh *et al.* 2016b), Belahi (Vohra *et al.* 2016b), Konkan (Singh *et al.* 2016a), Ladhakhi.

Buffalo: The Indian buffaloes (*Bos bubalus bubalus* and *Bos bubalus carabensis*) are mostly riverine (2n=50), though some swamp type buffaloes (2n=48) are also available in North-Eastern region in India. As per latest livestock census, 108.7 million buffaloes are available in India, representing more than 50% of the World buffalo population. Since 1951, the buffalo population in India has increased by 2.5 times. Presently, 17.05% of total Indian buffaloes belong to one or other indigenous breeds, whereas 39.58% are grades of 13 recognized breeds of Indian buffaloes. Still 43.37% of Indian buffaloes are classified as non-descript, which needs attention for identification of new populations deserving the status of a breed. Since inception of breed registration, 3 such buffalo populations were registered as new breeds. Studies were also conducted to characterize Indian buffalo breeds/populations through survey in their native tracts. The breeds/populations of buffalo include Toda (Nair *et al.* 1986), Nili-Ravi (Tantia *et al.* 1999, Vij and Tantia 2005), Bhadawari (Pundir and Ahlawat 2004a), Mehsana (Pundir and Ahlawat 2004b), Banni (Mishra *et al.* 2009), Assamese swamp and hill buffalo of NEH, Marathwadi, South Kanara, Buffaloes of Orissa, Gojri (Vohra *et al.* 2012), Buffaloes of Chhattisgarh (Vohra *et al.* 2016a), Bargur (Raja *et al.* 2016).

Goat: Goat (*Capra hircus*) is the second largest mammalian livestock species in India with a population of 135.17 million. Around 27% of total goat population represents pure indigenous breed and 11.77% grades of pure indigenous breeds. At the same time, a large proportion of 61.26% of goats are known as non-descript indigenous animals. The efforts for characterization of recognized breeds and identification of new breeds were made in last 2–3 decades. The breeds/populations of goat studied include Beetal (Tantia *et al.* 1999, 2001), Kodi Adu (Jain *et al.* 2000), Marwari (Dixit *et al.* 2007), Jakhrana (Verma *et al.* 2005a, 2007d), Gohilwadi (Verma *et al.* 2007b), Malabari (Verma *et al.* 2009), Sirohi, Changthangi goat (Mishra *et al.* 2010), Sangamneri (Verma *et al.* 2010b), Kutchi, Surti, Berari, Kanni Adu, Konkan Kanyal (Verma *et al.* 2012a), Surti (Dixit *et al.* 2013), Local goat of Odisha (Verma *et al.* 2015), Narayanpatna, Raigari, Malkangiri, Singhery, Local goat of Rohilkhand (UP) and Uttarakhand, Bundelkhandi goat (Mishra *et al.* 2012b), Sikkim black (Verma *et al.* 2014), Nagaland long hair goat (Verma *et al.* 2016).

Sheep: Total sheep (*Ovis aries*) population is 65.07 million in India. A larger portion of sheep in India is indigenous with 36.55% purebreds, 18.95% grades of different breeds and 38.69% non-descript animals. In sheep, crossbreeding by using exotic sheep breeds of fine wool was also attempted but restricted to some hilly states of India. This has resulted availability of 0.72% exotic breeds and 5.09% crossbreeds with exotic breeds. Presently, there are 42 breeds of indigenous and 3 breeds of exotic sheep. Attempts were made to systematically characterize the recognized breeds and other populations of indigenous sheep. The breeds/populations of sheep studied include Garole (Sahana *et al.* 2001), Jalauni (Sahana *et al.* 2004),

Kheri, Sonadi, Magra, Balangir, Nali, Chokla, Kenguri, Bellary, Mandya, Hassan, Muzaffarnagari (Kumar *et al.* 2006), Rampur Bushair (Dixit *et al*. 2005a), Nellore, Ganjam (Arora *et al.* 2010), Vembur, Munjal (Yadav *et al.* 2010a, 2011), Madras Red, Tiruchi Black, Sheep populations of Odisha, Koraput (Singh *et al.* 2015b), Ramnad White (Raja *et al.* 2012), Chevad, Patanwadi, Kajali (Mishra *et al.* 2014), Chitarangi (Mishra *et al.* 2016a) and Dumba.

Other livestock: Apart from above 4 livestock species, other species like pig (*Sus scrofa domesticus*), camel (*Camelus dromendaries*), horse (*Equus caballus*), yak (*Bos grunniens*) and mithun (*Bos frontalis*) are also available in India. The efforts for characterization of pig has resulted into recognition of 6 new breeds of indigenous pigs, which was previously represented mostly by non-descript pigs. Among the Indian pig population, 3.03% are purebred, 73.11% are indigenous non-descript, 2.33% are exotic breeds and rest 21.53% are crossbreds with exotic breeds. It is important to mention here that among all the mammalian livestock, maximum proportion of exotic purebreds and crossbreds of pigs are available in India. Presently, 6 exotic pig breeds are found in India. There are 9 breeds of camel, which represent 71.78% purebreds of total camel population of India and rest 28.22% of Indian camel belongs to non-descript indigenous category. Horses and ponies are largely represented as non-descript (80.43%) but 19.57% of horse population is represented by 6 breeds. Therefore, sincere efforts were also made for characterization and inventorization of these other livestock species. The breeds/populations of other livestock species studied include Spiti (Pundir 2001), Bhutia, Nukra, Manipuri horse, Indigenous donkey, Ankamali pig.

Poultry: Tremendous growth has been recorded in development of poultry population in India i.e., 73.5 million in 1951 to 729.21 million in 2012 (almost 10 times). Chicken (*Gallus domesticus*), the major avian species in India includes commercial strains and indigenous birds in backyard production system. Presently, there are 17 recognized indigenous chicken breeds, whose characterization was also given due emphasis in last 2–3 decades. The breeds/populations of poultry studied include Punjab Brown (Vij *et al.* 2006b), Chittagong, Daothigir, Aseel (Vij *et al.* 2006a), Danki (Vij *et al.* 2006a), Kalasthi (Vij *et al*. 2006a), Ghagus (Vij *et al*. 2006a), Busra, Tellichery, Harrighata black, Indian duck populations (Vij *et al.* 2012), Indigenous chicken of Manipur (Kaunayen).

Besides above breeds/populations, two populations of dog *viz.,* Rajapalayam and Chippiparai were also studied and characterized (Raja *et al.* 2015).

Characterization of Animal Genetic Resources under network project on AnGR

The Network Project on AnGR was initiated for systematic genetic characterization of large number of livestock and poultry distributed across India by ICAR. This project is being implemented through various agencies like State Agriculture Universities, State Animal Husbandry Departments, Other ICAR Institutes and NGOs with coordinating unit at NBAGR, Karnal (Haryana). The project was initiated in the later half of the VIII Five Year Plan and continues till date. Main objectives of the project included characterization of the breeds in terms of both qualitative and quantitative traits, development of breed descriptors for breeds, conservation of the germplasm of elite/unique and other animals. Standard formats for phenotypic characterization and development of breed descriptors were formulated and sets of questionnaires were developed for systematic survey for all the livestock species and poultry. Standard technical programme for survey and characterization of breed was also developed under the project. Stratified random sample survey was carried out in 3 districts of the home tract of the breed; under each district four strata were selected and in each stratum 5 villages were identified for survey. Thus, 60 villages were selected for the survey and characterization of the breed. Information on population size, herd size, management practices, socio-economic status of livestock keepers, native environment of the breeding tract, physical traits, morpho-metric traits, growth production and reproduction parameters and problems of the livestock keepers were recorded as per the pre-designed questionnaire. After collecting all the information and analysis of the data, a breed descriptor was developed for the breed/population under study. All the information along with the relevant photographs was compiled in form of a report/monograph. Various agencies from 18 states of India were involved during last 20 years to accomplish the phenotypic characterization of 50 livestock breeds/populations, which included 15 of cattle, 11 of sheep, 7 of goat, 4 of buffalo, 3 each of chicken and camel, 2 of mithun and one each of duck, yak, donkey, horse and pig. The breeds undertaken for phenotypic characterization till date under this project along with agencies involved are listed in the Table 2.

Characterization of Animal Genetic Resources under NATP projects of ICAR

National Agricultural Technology Project (NATP) was initiated by ICAR with the assistance of World Bank in 1998. Under this mega project, two sub-projects were sanctioned for animal genetic resource biodiversity, one under mission mode and other under production system research.

(i) *Sub-project on Animal Genetic Resource Biodiversity* (*Mission Mode*)*:* This project was sanctioned for a period of 4 years with lead center at NBAGR, Karnal and 11 co-operating centres. The project was aimed for phenotypic and molecular characterization of breeds, conservation of breeds in native tracts and characterization of commercially and economically important genes. In this project, 11 breeds considered for phenotypic characterization, were Bengal goat and Garole sheep at West Bengal University of Animal and Fisheries Sciences, Kolkata; Chegu goat at CSK, HPKV, Palampur (Himachal Pradesh); Desi cattle and buffalo of

Table 2. Phenotypic characterization under Network Project on AnGR

Breed and species	Five Year Plan	Name of the agency
Deoni cattle	VIII	Marathwada Krishi Vidyapeeth, Parbhani (Maharashtra)
Ongole cattle	VIII	Andhra Pradesh Agricultural University, Guntur (Andhra Pradesh)
Gir cattle	VIII	Gujarat Agricultural University, Anand (Gujarat)
Umblacherry cattle	VIII	TANUVASU, Chennai (Tamil Nadu)
Jaffarabadi buffalo	VIII	Gujarat Agricultural University, Junagarh (Gujarat)
Osmanabadi goat	VIII	MPKV, Rahuri (Maharashtra)
Barbari goat	VIII	CIRG, Makhdoom, Mathura (Uttar Pradesh)
Aseel poultry	VIII	IGKVV, Raipur (Presently in Chhattisgah)
Bachaur cattle	IX	Veterinary College, Patna (Bihar)
Dangi cattle	IX	BAIF, Pune (Maharashtra)
Amritmahal cattle	IX	University of Agriculture, Bangalore (Karnataka)
Nagpuri buffalo	IX	MAFSU, Nagpur (Maharashtra)
Changthangi sheep	IX	SKUA&ST-K, Srinagar (J&K)
Deccani sheep	IX	BAIF, Pune (Maharashtra)
Mecheri sheep	IX	TANVASU, Chennai (Tamil Nadu)
Attapaddy goat	IX	Veterinary College, Mannuthy (Kerala)
Kutchi camel	IX	Gujarat Agricultural University, Anand (Gujarat)
Spiti horse	IX	CSK HPKV, Palampur (Himachal Pradesh)
Arunachali mithun	IX	Animal Husbandry Department, Government of Arunachal Pradesh (Arunachal Pradesh)
Ankleshwar poultry	IX	GAU, Anand (Gujarat)
Khillar cattle	X	BAIF, Pune (Maharashtra)
Gaolao cattle	X	MAFSU, Nagpur (Maharashtra)
Surti buffalo	X	Navsari Agricultural University, Navsari (Gujarat)
Gangatiri cattle	X	UP Collage, Varanasi (Uttar Pradesh)
Tho Tho cattle	X	NRC on Mithun, Jharnapani, Medziphema, Dimapur (Nagaland)
Mandya sheep	X	KVASU, Bangalore (Karnataka)
Rampur bushair sheep	X	CSK HPKV, Palampur (Himachal Pradesh)
Banpala sheep	X	Animal Husbandry Department, Government of Sikkim (Sikkim)
Coimbatore sheep	X	Veterinary College, Namakkal (Tamil Nadu)
Chhotanagpuri sheep	X	Bisra Agricultural University, Ranchi (Jharkhand)
Ganjam goat	X	OUAT, Bhubaneshwar (Odisha)
Mehsana goat	X	Navsari Agricultural University, Navsari (Gujarat)
Assam cattle	XII	Assam Agricultural University, Guwahati (Asom)
Kosali cattle	XII	Veterinary College, Anjora, Durg (Chhattisgarh)
Binjharpuri cattle	XII	OUAT, Bhubaneshwar (Odisha)
Purnea cattle	XII	ICAR Complex for Eastern region, Patna (Bihar)
Dharwadi buffalo	XII	University of Agricultural Sciences, Dharwad (Karnataka)
Assam duck	XII	Assam Agricultural University, Guwahati (Asom)
Hazra chicken	XII	OUAT, Bhubaneshwar (Odisha)
Assam pig	XII	NRC on Pig, Guwahati (Asom)
Tibetan sheep	XII	ICAR Research Complex, Gangtok (Sikkim)
Marwari sheep	XII	CSWRI, ARC, Bikaner (Rajasthan)
Poonchi sheep	XII	SKUAST-J, Jammu (J&K)
Bhakarwal goat	XII	SKUAST-J, Jammu (J&K)
Bundelkhandi goat	XII	BAIF, Pune (Maharashtra)
Rajasthani donkey	XII	NRC on Equines, Bikaner (Rajasthan)
Marwari camel	XII	NRC on Camel, Bikaner (Rajasthan)
Jalori camel	XII	NRC on Camel, Bikaner (Rajasthan)
Nagami mithun	XII	NRC on Mithun, Jharnapani, Medziphema, Dimapur (Nagaland)
Arunachali yak	XII	NRC on Yak, Dirang (Arunachal Pradesh)

VIII Five Year Plan- 1992-1997; IX Five Year Plan- 1997-2002; X Five Year Plan- 2002-2007; XII Five Year Plan- 2012-2017. Cited from PC Report 2001, 2005, 2008 and 2016.

Kerala at Kerala Agricultural University, Mannuthy, Thrissur (Kerala); Bhadawari buffalo at Veterinary College, Mathura (Uttar Pradesh); Tarai buffalo at GB Pant University of Agriculture and Technology, Pantnagar (Uttarakhand); Miri Poultry at Assam Agricultural University, Khanapara, Guwahati (Asom); Nicobari Fowl at Central Agricultural Research Institute, Port Blair (Andaman & Nicobar Islands); Kashmir Favorolla Poultry at SKUAST-K, Srinagar (Jammu and Kashmir); Jaisalameri camel at National Research Center on Camel, Bikaner (Rajasthan) and Pugal sheep at CSWRI, Avikanagar (Rajasthan).

(*ii*) *Sub-project on Genetic characterization of important sheep and goat breeds of Arid-Zone* (*NATP-PSR*)*:* This project was sanctioned for a period of 4 years and the lead centre was at NBAGR, Karnal and 4 co-operating centres (Anonymous 2003). The project had the objectives of phenotypic-characterization and development of breed-descriptors, micro-satellite marker based genetic characterization and identification of unique characteristics of the breed. In this project, 7 breeds were considered for phenotypic characterization. These breeds included Malpura and Jaiselmeri sheep at CSWRI, Avikanagar (Rajasthan); Gaddi sheep and Gaddi goats at CSK, HPKV, Palampur (Himachal Pradesh); Karnah and Gurej sheep at SKUAST-K, Srinagar (Jammu and Kashmir) and Parbatsari goat at CAZRI, Jodhpur (Rajasthan).

Characterization of AnGR by State Universities/Animal Husbandry Departments

The characterization of AnGR was also done by several state Universities and Animal Husbandry departments. ICAR also provides financial support for such projects. Some of the breeds characterized under the support of ICAR include local hill fowl (Anonymous 2008i) and small hill cattle of Kumaon (Anonymous 2005) by GB Pant University of Agriculture and Technology, Pantnagar; Malvi cattle, Nimari cattle and Kenkatha cattle (Tomar and Joshi 2008) by JNKVV, Jabalpur; Khillar cattle by MPKV, Rahuri; Kangayam cattle at Veterinary College and Research Institute, Namakkal, Tamil Nadu (Anonymous 1997) and Marathwadi buffalo at Marathwada Krishi Vidyapeeth, Parbhani (Maharashtra); Teressa goat at Central Agriculture Research Institute, Port Blair (Anonymous 2007) and Hallikar cattle at Veterinary College, Bangalore (Anonymous 2008h).

Some of the state Animal Husbandry Departments have done commendable job for characterization of animal genetic resources e.g. Odisha Livestock Resources Development Society, Bhubaneswar has completed the characterization of Binjharpuri, Motu, Ghumsuri and Khariar cattle; Chilika and Kalahandi buffaloes and got them registered with registration system of livestock and poultry breed developed by ICAR at NBAGR, Karnal. This agency has also published breed monographs giving details about the breed. Some of other breed characterization was done by state Universities like Surti goat of Gujarat (Deshpande *et al.* 2010a), Toda buffalo of Tamil Nadu (Karthickeyan *et al.* 2002a,b), Chilika buffaloes of Odisha (Patro *et al.* 2003), Changthangi goats of Ladakh (Bhattacharya *et al.* 2004), Ghoongroo pig of West Bengal (Pan *et al.* 2005), Mewari and Jaisalmeri camel of Rajasthan (Mehta *et al.* 2007), Munjal sheep of Haryana (Kushwaha *et al.* 1999), Salem Black goats of Tamil Nadu (Thiruvenkadan and Krunanithi 2006) and Vechur cattle of Kerala (Iype 1996).

Registration and documentation of AnGR

The registration of livestock and poultry genetic resources was initiated to protect and check biopiracy of indigenous AnGR. NBAGR, Karnal is the nodal agency for the registration of newly identified germplasm of the livestock and poultry of the country. Accession numbers have been given to each of extant breeds of various species of livestock and poultry have been published as special feature in *The Indian Journal of Animal Sciences*. The details can be viewed on the website of NBAGR (www.nbagr.res.in). A total of 31 new breeds were registered from 2010 to 2016. After including these newly registered breeds, total number of indigenous breeds in the country will now be 160, which include 40 breeds of cattle, 13 buffalo, 26 goat, 42 sheep, 6 horse and pony, 9 camel, 6 pig, 1 donkey and 17 of chicken. The registration shall be carried out using a well laid breed descriptor which was evolved by the Bureau. An alpha numeric code was designed for all the breeds in the following format:

INDIA_SPECIES NAME_ABCD_BREED NAME_ XYEFG

AB = Two Digit Numeric Code for State One (Major Tract)
CD = Two Digit Numeric Code for State Two
XY = Two Digit Numeric Code for Species
EFG = Three Digit Numeric Code for the Breed

The breed descriptors include information on general description of the breed (breed name), its synonyms, native tract of distribution, estimated population and herd size, description of the communities rearing the breed, utility of the breed, physical and morpho-metric characters and performance of the breed etc. So far breed descriptors of 116 breeds of livestock and poultry have been published in *The Indian Journal of Animal Sciences*. These include Pandharpuri, Bhadawari, Surti and Nagpuri buffaloes (Anonymous 2008a); Changthangi, Jakhrana and Gohiwadi goat (Anonymous 2008b); Umblachery, Deoni, Ongole and Gir cattle (Anonymous 2008c); Marathwadi, Mehsana, Toda and Jaffarabadi buffaloes (Anonymous 2008d); Amritmahal, Dangi, Bachaur and Khillar cattle (Anonymous 2008e); Chokla, Chhotanagpuri, Nali, Sonadi sheep (Anonymous 2008f); Gaolao, Malvi, Nimari and Kangayam cattle (Anonymous 2008g); Mehsana, Chegu, Beetal, Kutchi, Marwari, Malabari, Ganjam, Attapady black, Sirohi, Barbari goat (Anonymous 2009a); Marwari, Kathiawari, Manipuri, Spiti horse (Anonymous 2009b); Bhakarwal, Bonpala, Changthangi, Coimbatore, Gaddi, Garole, Kanguri, Malpura, Muzaffarnagari and Pugal sheep (Anonymous 2009c); Hallikar, Hariana, Kankrej, Mewati,

Table 3. List of breeds documented through publication of monograph/bulletins

S.No.	Name of the breed	Reference	S.No.	Name of the breed	Reference
1.	Red Kandhari cattle	Pundir *et al.* (2005)	52	Ganjam goat	Dash *et al.* (2006)
2.	Sahiwal cattle	Prakash *et al.* (2005)	53	Malabari goat	Verma *et al.* (2008)
3.	Deoni cattle	Singh *et al.* (2006f)	54	Sangamneri goat	Verma *et al.* (2010a)
4.	Gir cattle	Singh *et al.* (2006d)	55	Konkan Kanyal goat	Verma *et al.* (2011)
5.	Hallikar cattle	Singh *et al.* (2006e)	56	Barari goat	Verma *et al.* (2012b)
6.	Kenkatha cattle	Pundir *et al.* (2006b)	57	Bundelkhandi goat	Verma and Mishra (2014)
7.	Ongole cattle	Pundir *et al.* (2006a)	58	Surti goat	Deshpande *et al.* (2010b)
8.	Ponwar cattle	Sharma *et al.* (2007)	59	Mecheri sheep	Karunanithi *et al.* (2004)
9.	Kherigarh cattle	Pandey *et al.* (2007)	60	Coimbatore sheep	Kandasamy *et al.* (2006)
10.	Red sindhi cattle	Pundir *et al.* (2007b)	61	Banpala sheep	Bhutia *et al.* (2006)
11.	Mewati cattle	Singh *et al.* (2007d)	62	Rampur Bushaire sheep	Katoch *et al.* (2006)
12.	Kankrej cattle	Sodhi *et al.* (2006)	63	Munjal sheep	Yadav *et al.* (2010b)
13.	Bargur cattle.	Pundir *et al.* (2008)	64	Garole sheep	Arora *et al.* (2005)
14.	Purnea cattle	Sharma *et al.* (2012b)	65	Kheri sheep	Bhatia *et al.* (2005)
15	Motu cattle	Sethi and Dash (2007a)	66	Nali sheep	Singh *et al.* (2006a)
16	Khariar cattle	Sethi and Dash (2009)	67	Chokla sheep	Jain *et al.* (2005c)
17	Binjharpuri cattle	Sethi and Dash (2007b)	68	Mandya sheep	Jain *et al.* (2005b)
18	Nimari cattle	Sarkhel (2001)	69	Kenguri sheep	Jain *et al.* (2006b)
19	Malvi cattle	Srivastava *et al.* (2002)	70	Sonadi sheep	Jain *et al.* (2006c)
20	Hariana cattle	Joshi *et al.* (1995)	71	Hassan sheep	Jain *et al.* (2006a)
21	Nagori cattle	Vij *et al.* (1997)	72	Bellary sheep	Jain *et al.* (2005a)
22	Tharparkar cattle	Nivsarkar *et al.* (1992)	73	Marwari sheep	Singh *et al.* (2007a)
23	Belahi cattle	Vohra *et al.* (2014)	74	Karnah sheep	Gupta *et al.* (2007b)
24	Tho Tho cattle	Dhali *et al.* (2006)	75	Gurej sheep	Gupta *et al.* (2007e)
25	Gangatiri cattle	Singh *et al.* (2006c)	76	Malpura sheep	Gupta *et al.* (2007d)
26	Gaolao cattle	Kothekar *et al.* (2006)	77	Jaiselmeri sheep	Gupta *et al.* (2007c)
27	Khillar cattle	Gokhale *et al.* (2006)	78	Jalauni sheep	Arora *et al.* (2007)
28	Vechur cattle	Iype and Venkatac-halapathy (2001)	79	Ganjam sheep	Arora *et al.* (2008)
29	Bhadawari buffalo	Kataria *et al.* (2005)	80	Madras red sheep	Mishra *et al.* (2013)
30	Murrah buffalo	Sadana *et al.* (2006)	81	Koraput sheep	Singh *et al.* (2015c)
31	Nili Ravi buffalo	Kathiravan *et al.* (2007a)	82	Kajali sheep	Mishra *et al.* (2016b)
32	Nagpuri buffalo	Kataria *et al.* (2007)	83	Spiti horse	Behl *et al.* (2005a)
33	Jaffrabadi buffalo	Kathiravan *et al.* (2007b)	84	Ankamali pig	Gupta *et al.* (2007a)
34	Pandharpuri buffalo	Mishra *et al.* (2007)	85	Marwari horse	Gupta *et al.* (2007f)
35	South Kanara buffalo	Kathiravan *et al.* (2010)	86	Kathiawari horse	Gupta *et al.* (2007g)
36	Banni buffalo	Mishra *et al.* (2012a)	87	Jaisalmeri camel	Behl *et al.* (2010)
37	Toda buffalo	Kathiravan *et al.* (2012)	88	Spiti donkey	Behl *et al.* (2005)
38	Marathwadi buffalo	Kataria *et al.* (2012)	89	Sindhi donkey	Behl *et al.* (2013)
39	Chilika buffalo	Sethi *et al.* (2007)	90	Miri poultry	Vijh *et al.* (2005a)
40	Surti buffalo	Kharadi *et al.* (2006)	91	Aseel poultry	Pandey *et al.* (2005)
41	Barbari goat	Sharma *et al.* (2005)	92	Ankleshwar poultry	Tantia *et al.* (2006)
42	Chegu goat	Aggarwal *et al.* (2005)	93	Kalasthi poultry	Vijh *et al.* (2005b)
43	Jakhrana goat	Verma *et al.* (2005b)	94	Danki poultry	Vij *et al.* (2005a)
44	Marwari goat	Dixit *et al.* (2005b)	95	Ghagus poultry	Tantia *et al.* (2005b)
45	Beetal goat	Sharma *et al.* (2006)	96	Daothigir fowl	Vij *et al.* (2006c)
46	Sirohi goat	Verma *et al.* (2007c)	97	Nicobari fowl	Vijh *et al.* (2006)
47	Kutchi goat	Dixit *et al.* (2006)	98	Punjab brown	Vij *et al.* (2005b)
48	Gohilwadi goat	Verma *et al.* (2007a)	99	Kashmir Faverolla	Tantia *et al.* (2005a)
49	Attapaddy goat	Aggarwal *et al.* (2007a)	100.	Tellichery	Vij *et al.* (2007a)
50	Changthangi goat	Aggarwal *et al.* (2007b)	101	Red Jungle fowl	Vijh *et al.* (2007)
51	Mehsana goat	Singh *et al.* (2006b)	102	Busra chicken	Vij *et al.* (2007b)

Nagori, Punganur, Rathi, Sahiwal, Siri, Vechur cattle (Anonymous 2009d); Motu, Ghumsuri, Binjharpuri and Khariar cattle; Banni and Chilika buffalo (Anonymous 2010); Ankaleshwar, Aseel, Busra, Danki, Daothgir, Ghagus, Kadaknath, Kalasthi, Kashmiri Faverolla, Miri, Nicobari, Punjab Brown and Tellichery chicken (Anonymous 2011); Black Bengal, Gaddi, Jamunapari, Kanni Adu, Osmanabadi, Sangamneri, Surti and Zalawadi goat (Anonymous 2012); Bellary, Gurez, Hassan, Karnah, Kilakarsal, Madras Red, Magra, Mandya, Nilgiri, Ramnad white, Rampur bushaire, Tibetan sheep (Anonymous 2013a); Pulikulam, Kosali and Malnad Gidda cattle; Kalahandi buffalo; Konkan Kanyal and Berari goat; Spiti donkey; Ghoongroo and Niang Megha pig (Anonymous 2013b); Belahi and Gangatiri cattle; Pantja goat; Katchaikatty black sheep; Kharai camel; Agonda goan pig and Mewari chicken (Anonymous 2015).

For documentation of indigenous livestock breeds, NBAGR, State Animal Husbandry Departments and many other Agricultural/Veterinary universities publish breed monographs/bulletins and up till now more than 100 monographs have been published by different organizations (Table 3). After completing phenotypic and/or genetic characterization of the breed, a document of about 30–80 pages were prepared by different authors. Such documents/ breed monographs included information on different aspects of management, breed characteristics, genetic characterization, growth/reproduction/production performance collected during the survey and characterization as well as available in the literature. Some of the authors of such monographs included the historical aspects of the breeds as well as plans for further development and conservation of the breed. These breed monographs also provided good photographs of the breed and the management practices prevailing in their respective breeding tracts. Some of the monographs published by different agencies are listed in the Table 3. ICAR-NBAGR, Karnal, has also released the breed charts/calendars for cattle, buffalo, sheep, goat and chicken species in which one male and one female animal of all the breeds of that species are depicted.

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