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Assessment of degree of endangerment of livestock breeds in India

P K SINGH[1] and ARJAVA SHARMA[2]

ICAR-National Bureau of Animal Genetic Resources, Karnal, Haryana 132 001 India

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ABSTRACT

Complete national inventories, supported by periodic monitoring of trends and associated risks, are basic requirements for the effective management of farm animal genetic resources. Government of India conducted breed survey in 2013 to estimate breed-wise data for livestock belonging to different categories, breeds, age and sex groups. FAO has developed criteria for assessment of risk to the livestock breeds, which were used to assess the risk status of all the breeds of livestock species. Breed-wise populations of breeding males and females, overall population size, effective population size and rate of inbreeding were estimated. Cattle, sheep and pigs species were classified as indigenous purebreds, graded to indigenous breeds, indigenous non-descript, exotic purebreds and crossbreds to exotic breeds; while buffalo and goat species were classified under first three categories only. Proportion of indigenous purebreds of cattle, buffalo, sheep, goat and pig were found as 9.4, 17, 36.6, 27 and 3%, respectively of the total population of the species; whereas corresponding figures of graded to indigenous breeds and non-descript animals were estimated to be 10.5, 39.6, 18.9, 11.8 and 0% and 59.3, 43.4, 38.7, 61.2 and 73.1%, respectively. Large non-descript proportion of all the livestock species should be screened for identification, characterization and registration of new breeds. Exotic breeds and crossbreds to exotic breeds in cattle, sheep and pig were obtained as 0.7 and 20.1%; 0.7 and 5.1% and 2.3 and 21.6%, respectively of total population. The rate of inbreeding estimated for most of the breeds were well below 0.5% except for Mewati (1.193%), Pullikulam (0.72%) and Vechur (17.893%) cattle breeds and Chilika (0.731%) buffalo breed. Using the FAO criteria, Bargur and Siri cattle breeds and Attapadi goat breeds were categorized under vulnerable status of risk; Krishna Valley, Mewati, Pullikulam and Punganur cattle breeds, Chilika and Toda buffalo breeds and Karnah and Poonchi sheep breeds under endangered status of under risk and Vechur cattle under critical status of risk. All these breeds need immediate steps for rescue by using suitable conservation methodology. Breed-wise census should be continued in future so that trends in breed populations may also be estimated for fine tuning of risk assessment of breeds.

Key words: Effective population size, Endangered, Rate of inbreeding, Risk status, Vulnerable

Livestock diversity and options for its utilization are usually discussed in terms of breeds. "Breeds" are cultural concepts rather than physical entities. The Strategic Priorities for Action, contained within this Global Plan of Action for Animal Genetic Resources (FAO 2007b), proposes specific measures to reverse the ongoing trends of erosion and under-utilization of animal genetic resources. The extent and rate of loss of animal genetic resources are still difficult to estimate, despite the better picture of animal genetic resources that has emerged in the country-driven preparation of *The State of the World's Animal Genetic Resources* (FAO 2007a, FAO 2015). The lack of information hinders decision-making with regard to what to conserve and develop, and how to best use limited funds available for conservation. Understanding the diversity, distribution, basic characteristics, comparative performance and the current status of animal genetic resources is essential for their efficient and sustainable use, development and conservation. Complete national inventories, supported by periodic monitoring of trends and associated risks, are the basic requirements for the effective management of animal genetic resources. Without such information, some breed populations and unique characteristics they contain may decline significantly, or be lost, before their value is recognized and measures are taken to conserve them.

Government of India initiated breed-wise livestock census in 2007 but this census could only provide total population of livestock breeds. The Breed Survey 2013 (DADF 2015) conducted during livestock census 2013 provided for the first time the breed-wise data on number of breedable males and females and of other age groups along with graded population for various livestock species. The data generated in this survey was analyzed on the criteria laid down by FAO (FAO 2013) so as to assess the degree of endangerment associated with livestock breeds in India. The inference drawn in this paper will be helpful in better understanding of domestic animal diversity and making decision for its conservation and genetic improvement.

Present address: [1]Principal Scientist (pksinghmathura@gmail.com), [2]Director(arjava@yahoo.com).

MATERIALS AND METHODS

Basic data used in the study: During 19th Livestock Census, a separate breed survey was conducted on 15% sample of villages to estimate breed-wise livestock population. A total of 98, 574 sample villages were selected using Simple Random Sampling Without Replacement (SRSWOR) method. Thus the livestock population was an estimated population of livestock species and their breeds presented in the Breed Survey Report published in 2015 (DADF 2015). Breed survey was successfully completed with reference date of 31.07.2013 across the country in the selected villages where complete enumeration was done in all identified breeds in 13 selected species of animals. In view of the economic significance, top five mammalian species, representing 99.63% of total livestock population of India (DADF 2014), i.e. cattle, buffalo, sheep, goat and pig were considered in this study.

Sample design: As per DADF (2015), the sample design adopted in the survey was Stratified Random Sampling with each sub-district as single stratum. The first stage units were census villages in rural areas as per 2011 census. In case of Kerala, the *panchayat* wards were considered as First Stage Units (FSU) in rural areas. From each stratum (sub-district), 15% of villages were selected randomly in rural sector based on SRSWOR. The selection process under Breed Survey was carried out through online mode using the software generated by National Informatics Centre, Chhattisgarh in which login ID and password were given to each state in addition to the admin login facility. In urban sector, the urban pockets which were identified by the States/UTs were surveyed on complete enumeration basis. For any uninhabited villages selected in the sample, corresponding substitute villages were also provided. In Breed Survey, the second stage units were households and ultimate and third stage units were animals belonging to a particular breed. Sample proportion of each breed say '*p*'for the sub-district was used as an estimate of population proportion of the particular breed in that sub-district. The sample proportion, '*p*', was estimated by dividing total number of animals in the breed in the selected category by total number of animals in the selected category in all breeds of same species. This sample ratio was used for estimating the population proportion of animals in the particular category by disintegrating into census figures of 19th Livestock Census for every sub-district. The sub-district estimates were further added for arriving at district level as well as state level estimates.

DADF (2015) has provided the estimates of five categories i.e. pure breeds, graded to the breeds, non-descript, exotic and crossbreds for cattle, sheep and pig and only first three categories for other species. For each of the category; within species, sex-wise and age-wise estimates were reported. In the present study, number of breeding males and breeding females were used for estimation of effective population size. For cattle, buffalo and goats, animals in milk and dry were assumed to be the breeding females whereas in sheep, females above one year and in pigs, females above 6 months were considered as breeding females.

Effective population size (N_e) and rate of inbreeding (ΔF)*:* Effective population size was estimated as per the simplest model suggested by Wright (1931) by taking into account the fact that the number of breeding males and females are unequal i.e. $Ne=(4*N_M*M_F)/(N_M+N_F)$. In this model, it is assumed that there is random mating; no selection and equal number of progenies are produced by each breeding animal. If the selection is operating in the population, even selection based on phenotype, Wright's formula overestimates the Ne resulting in to under estimation of ΔF. In such circumstances, Santiago and Caballero (1995) suggested to adjust the Ne by multiplying with a factor of 0.7. Thus adjusted Ne was estimated as original Ne multiplied by 0.7. Rate of Inbreeding (ΔF) was worked out by using the formula $\Delta F=1/(2Ne)$, where Ne is adjusted Ne as suggested by Santiago and Caballero (1995). Any rate of inbreeding below 0.001% was considered as zero in the present study.

Risk status classification of breeds: The criteria laid down by FAO were considered to classify the breeds as per their risk status classes. As per FAO (2013), the risk status classification for Bovidae family (low reproductive capacity species) has been given. It includes seven categories namely *Extinct, w*hen there is no breeding male or female remaining and any cryo-conserved genetic material that may be available is insufficient for breed reconstitution; *Cryo-conserved only,* When there is no living male or female animals remaining but for which there is sufficient cryo-preserved material to allow for reconstitution of the breed; *Critical,* a breed is categorized as critical, if the total number of breeding females is less than or equal to 300 or the overall population size is less than or equal to 240 and the population trend is increasing and the proportion of females being bred to males of the same breed is greater than 80% or the overall population size is less than or equal to 360 and the population trend is stable or decreasing or the total number of breeding males is less than or equal to five (i.e. Δ F is 3% or greater). If the population trend is unknown, then it is assumed to be stable. This may be called as "Critical-maintained", if active conservation programmes are in place or populations are maintained by commercial companies or research institutions; *Endangered,* a breed is categorized as endangered, if the total number of breeding females is greater than 300 and less than 3,000 or the overall population size is greater than 240 and less than 2,400 and the population trend is increasing and the proportion of females being bred to males of the same breed is greater than 80% or the overall population size is greater than 360 and less than or equal to 3,600 and the population trend is stable or decreasing or the total number of breeding males is greater than five but less than or equal to 20 (i.e. Δ F is between 1 to 3%). If the population trend is unknown, then it is assumed to be stable. This may be called as "Endangered-maintained", if active conservation programmes are in place or populations are maintained by

commercial companies or research institutions; *Vulnerable,* a breed is categorized as vulnerable, if the total number of breeding females is between 3,000 to 6,000 or the overall population size is greater than 2,400 and less than or equal to 4,800 and the population trend is increasing and the proportion of females being bred to males of the same breed is greater than 80% or the overall population size is greater than 3,600 and less than or equal to 7,200 and the population trend is stable or decreasing or the total number of breeding males is between 20 to 35 (i.e. Δ F is between 0.5 to 1%). If the population trend is unknown, then it is assumed to be stable; *Not at risk,* if the population status is known and the breed does not fall in any of above categories; *Unknown,* if the population data is not available for the breed.

It is important to note that pig is considered as high reproductive capacity species, therefore, breedable female population and overall population size of the breed in the above said criteria will be one third of the figures given for low reproductive category species (cattle, buffalo, sheep and goat) and all other criteria will remain the same.

RESULTS AND DISCUSSION

Broader classification of livestock species: Broader classification of cattle, buffalo, sheep, goat and pig species is given in the Table 1. Analysis of the data of breed survey 2013 (DADF 2015) indicated that cattle and sheep species may be classified in to five broad categories i.e. indigenous breeds, indigenous graded, non-descript indigenous, exotic breeds and crossbreds of exotic breeds. In cattle species, the proportion of indigenous purebreds, graded to indigenous breeds, indigenous non-descript, exotic purebreds and crossbreds of exotic breeds were 9.4, 10.5, 59.3, 0.7 and 20.1%, respectively and in sheep species corresponding proportions were 36.6, 18.9, 38.7, 0.7 and 5.1%, respectively. The number of crossbred cattle increased by 4.4% and that of exotic cattle decreased by 0.2% as compared to Livestock census 2007, whereas number of exotic sheep increased by 0.5% and that of crossbred sheep decreased by 0.8% during the same period. During 2007–2013, the proportion of non-descript cattle and non-descript sheep also reduced by 10.4% and 10.1%, respectively. In cattle, this may be due to the fact that proportions of crossbred and graded animals increased. In case of sheep, indigenous breeds and non-descript both decreased, therefore, proportion of graded animals increased. Species of buffalo and goat were classified into three categories i.e. indigenous purebreds, graded to indigenous breeds and indigenous non-descript; which were 17, 39.6 and 43.4%, respectively in buffaloes and 27.0, 11.8 and 61.2%, respectively in goat. In both these species, number of indigenous purebreds (13.2% buffalo and 7.1% goat) and non-descript indigenous animals (12.7% buffalo and 2.3% goat) decreased and that of graded to indigenous breeds animals were increased in 2013 as compared to 2007. It is important to note that in Breed Survey 2013, the graded indigenous animals were separately recorded as grades of different indigenous breeds. Pig species was classified into four categories i.e. indigenous breeds, non-descript indigenous, exotic breeds and crossbreds of exotic breeds which were 3.0, 73.1, 2.3 and 21.6%, respectively. Number of exotic and crossbred pig increased marginally as compared to last census of 2007. The breed survey also gave group-wise headcounts of animals including number of breeding males and females, which was used for classifying the breeds into their risk status categories. It is important to mention here that large proportions of non-descript animals in all the livestock species should be screened for presence of any homogenous population deserving the status of breed. Such populations should be studied and registered under the Livestock Breed Registration system developed by ICAR. So far, in this system, 31 livestock and poultry populations have been registered as new breeds in last eight years.

Population status of livestock breeds: Population size and rate of change in population size are the most important factors influencing risk of extinction of a breed. In India, the population size of breeds in terms of breeding males and females were estimated for the first time in Breed Survey 2013; therefore the rate of change is not available. However, the assessment of breed's risk of extinction in this study is based on population size of breeding males and females. Population status in terms of number of breeding males, breeding females, overall population size, effective population size and rate of inbreeding of cattle, buffalo, sheep, goat and pig species is given in the Table 2.

In cattle species, a total 37 breeds of indigenous origin and 2 breeds of exotic origin were included in the breed survey 2013. The total population of different breeds varied

Table 1. Broad classification of Indian Livestock as per Breed Survey 2013

Species	Population (in thousands)							
	Indigenous breeds	Graded	Non descript indigenous	Indigenous animals	Exotic breeds	Crossbreds	Total exotic & crossbred	Total
Cattle	17849 (9.4)	20070 (10.5)	113253 (59.3)	151172 (79.2)	1320 (0.7)	38412 (20.1)	39732 (20.8)	190904
Buffalo	18534 (17.0)	43026 (39.6)	47142 (43.4)	108702 (100)	-	-	-	108702
Goat	36456 (27)	15906 (11.8)	82811 (61.2)	135173 (100)	-	-	-	135173
Sheep	23783 (36.6)	12329 (18.9)	25176 (38.7)	61288 (94.2)	465 (0.7)	3316 (5.1)	3781 (5.8)	65069
Pig	312 (3)	—	7526 (73.1)	7838 (76.1)	240 (2.3)	2216 (21.6)	2456 (23.9)	10294

Figures in parentheses indicate percent of total population

Table 2. Population status of Livestock breeds of India as per Breed Survey 2013

Species/Breed	Breeding males	Breeding females	Total population	Adjusted effective population size (0.7 Ne)	Rate of inbreeding (%) ΔF
Indigenous cattle (*Bos indicus*)					
Amritmahal	616	19543	105343	1672	0.030
Bachaur	10774	203179	741432	28648	0.002
Bargur	624	5939	14154	1581	0.032
Binjharpuri	268	20958	79428	741	0.067
Dangi	2995	24743	119373	7481	0.007
Deoni	1758	44068	151236	4734	0.011
Gaolao	1446	33981	121538	3884	0.013
Ghumsuri	532	13742	58855	1434	0.035
Gir	23545	520015	1380208	63070	0.001
Hallikar	5524	397357	1211242	15255	0.003
Hariana	11916	636506	1639181	32752	0.002
Kangayam	3897	30033	80620	9658	0.005
Kankrej	31570	810797	1945094	85083	0.001
Kenkatha	4360	147823	393291	11858	0.004
Khariar	2133	60093	290015	5768	0.009
Kherigarh	508	27709	75116	1397	0.036
Khillar	10975	298348	1102359	29640	0.002
Kosali	21951	698279	2431859	59590	0.001
Krishna Valley	126	1531	3462	326	0.153
MalnadGidda	16580	365263	899091	44408	0.001
Malvi	13547	402645	1158172	36697	0.001
Mewati	15	7206	14773	42	1.193
Motu	5244	112103	469320	14027	0.004
Nagori	2759	191201	373224	7615	0.007
Nimari	1122	87117	341828	3102	0.016
Ongole	1703	25126	115905	4466	0.011
Ponwar	61	8978	20067	170	0.295
Pullikulam	25	2977	7352	69	0.720
Punganur	77	1077	2772	201	0.248
Rathi	10502	408093	865921	28668	0.002
Red Kandhari	2263	63166	235058	6117	0.008
Red Sindhi	518	18584	59642	1411	0.035
Sahiwal	8442	431978	1092459	23185	0.002
Siri	89	4098	12171	244	0.205
Tharparkar	3474	89780	197291	9365	0.005
Umblacherry	586	15159	39050	1580	0.032
Vechur	1	494	1065	3	17.893
Exotic cattle (*Bos taurus*)					
Jersey	5899	325845	675647	16223	0.003
Holstein Friesian	4720	317145	643859	13022	0.004
Buffalo (*Bos bubalus bubalus*)					
Bhadawari	5021	258782	583599	13791	0.004
Banni	4335	128482	239572	11742	0.004
Chilika	25	1059	2599	68	0.731
Jaffarabadi	6902	302813	571077	18895	0.003
Kalahandi	1082	33350	115213	2934	0.017
Marathwada	1937	150750	278502	5355	0.009
Mehsana	24448	1346617	2676699	67234	0.001
Murrah	75799	5452183	11686198	209327	0.000
Nagpuri	1151	40752	73584	3134	0.016
Nilli Ravi	630	68288	129411	1748	0.029
Pandharpuri	2050	165949	287751	5670	0.009
Surti	9999	873671	1886280	27680	0.002
Toda	203	1213	3003	487	0.103

(Contd...)

Species/Breed	Breeding males	Breeding females	Total population	Adjusted effective population size (0.7 Ne)	Rate of inbreeding (%) ΔF
Indian sheep (*Ovis aries*)					
Bhakarwal	6570	53077	82334	16370	0.003
Bellari	131773	1022009	1673154	326825	0.000
Bolangir	50560	109262	248986	96783	0.001
Bonpala	42218	83659	231860	78564	0.001
Changthangi	18134	27877	65115	30764	0.002
Chokla	19182	149971	261514	47619	0.001
Chhotanagpuri	101821	201626	516692	189434	0.000
Coimbatore	2965	17972	28725	7126	0.007
Deccani	287886	2255647	3723406	714846	0.000
Gaddi	45702	152501	295010	98459	0.001
Ganjam	13634	44372	87597	29202	0.002
Garole	30877	61726	165531	57628	0.001
Gurez	3757	7208	17207	6915	0.007
Hassan	102973	356007	703012	223638	0.000
Jaisalmeri	112169	561256	1018880	261760	0.000
Jalauni	15754	42552	86072	32193	0.002
Karnah	269	1550	2946	642	0.078
KashmirMerino	5740	16189	37418	11865	0.004
Kenguri	17509	145305	243023	43753	0.001
Kilakarsal	6109	20043	37114	13109	0.004
Madrasred	38548	166321	311533	87626	0.001
Magra	69890	256989	507915	153851	0.000
Malapura	17945	144267	245251	44687	0.001
Mandya	43872	116436	244468	89223	0.001
Marwari	273558	1748785	3074952	662352	0.000
Mercheri	143325	645572	1212225	328401	0.000
Muzzafarnagri	19297	44359	99328	37652	0.001
Nellore	543906	4164649	6942182	1347016	0.000
Patanwadi	59699	282289	472997	137977	0.000
Poonchi	381	1362	2643	834	0.060
Pugal	10326	56849	99579	24468	0.002
Ramnad White	102567	325912	710028	218442	0.000
Rampur Bushair	4618	11732	23600	9278	0.005
Shahbadi	16203	26775	71278	28264	0.002
Sonadi	14237	95907	157694	34711	0.001
Tiruchi Black	9549	20781	47493	18319	0.003
Vembur	6020	14267	34086	11854	0.004
Exotic sheep (*Ovis aries*)					
Corridale	4902	16339	32763	10558	0.005
Merino	30647	71812	161582	60144	0.001
Rambouillet	31779	93700	270902	66446	0.001
Goat (*Capra hircus*)					
Attapadi Black	1303	4601	10238	2843	0.018
Barbari	304565	973230	2194443	649520	0.000
Beetal	43847	199554	379314	100655	0.000
Black Bengal	2930807	6383752	17408780	5624177	0.000
Changthangi	49764	80032	196210	85916	0.001
Chegu	4391	18258	36149	9911	0.005
Gaddi	48710	193161	363872	108921	0.000
Ganjam	56301	139484	317063	112310	0.000

(Contd...)

(Concluded Table 2)

Species/Breed	Breeding males	Breeding females	Total population	Adjusted effective population size (0.7 Ne)	Rate of inbreeding (%) ΔF
Gohilwadi	11026	104794	168917	27934	0.002
Jakhrana	42126	535268	989578	109347	0.000
Jamunapari	215954	707345	1599366	463242	0.000
Kannaiadu	106327	281932	696219	216184	0.000
Kutchi	28779	234575	380723	71775	0.001
Malabari	38818	235678	569531	93320	0.001
Marwari	377577	2923215	5347830	936281	0.000
Mehsana	55942	286598	521898	131056	0.000
Osmanabadi	159789	1341449	2481020	399788	0.000
Sanganeri	8923	93020	162834	22798	0.002
Sirohi	102794	1023764	1822729	261560	0.000
Surti	37487	128331	270834	81234	0.001
Zalawadi	32109	234694	390800	79085	0.001
Berari	10691	64002	120936	25650	0.002
KonkanKanyal	2868	14878	27039	6733	0.007
Indian Pig (*Sus scrofa domesticus*)					
Ghoongroo	39841	47702	184307	60786	0.001
NianMegha	33401	29613	127292	43950	0.001
Exotic Pig (*Sus scrofa domesticus*)					
Australian Large Black	187	235	876	292	0.171
Duroc	693	552	3323	860	0.058
Hampshire	6659	7904	29165	10120	0.005
Landrace	7117	9046	30063	11153	0.004
Saddleback	119	201	500	209	0.239
Yorkshire	43811	52284	175933	66744	0.001

from 1,065 (Vechur) to 24.32 lakhs (Kosali). However, population of Gir, Hallikar, Hariana, Kankrej, Khillar, Malvi and Sahiwal breeds was also above 10 lakhs. A total of 23 cattle breeds of Indian origin and 2 of exotic origin had overall population size of more than one lakh. Four breeds of Indian origin had population size of less than 10,000 and the population of rest ten was in between 10,000 to one lakh. Perusal of population of breeding female of different breeds indicated that eight breeds were less than 10,000 of which only six breeds (Bargur, Krishna Valley, Pullikulam, Punganur, Siri and Vechur) could be classified as 'at risk' i.e. less than six thousand. Breeding male population of Mewati (15), Pullikulam (25) and Vechur (1, which was reported to be used for breeding as well draft use) breeds was less than 35, bringing these breeds at risk but in the other breeds, breeding male population ranged from 61 in Ponwar to 31,570 in Kankrej. Overall population of different buffalo breeds varied from 2,599 (Chilika) to 116.86 lakhs (Murrah). Since Murrah is an improver breed of buffalo used throughout India and outside India, it is recognized as International transboundry breed of buffalo by FAO. The population size of ten breeds of buffalo was above one lakh and only of Chilika (2,599), Nagpuri (73,584) and Toda (3,003) numbered in thousands. Likewise, the breeding females of Chilika (1,059) and Toda (1,213) were too less, therefore, may be kept them 'at risk'. In Chilika (25), breeding males were also less than 35, which put the breed at risk.

Overall population size of 37 sheep breeds of Indian origin and 3 of exotic origin but reared in India varied from 2,643 (Poonchi) to 69.42 lakhs (Nellore). Many other breeds like Bellari, Deccani, Jaiselmeri, Marwari and Mecheri were more than 10 lakhs and Chhotanagpuri, Hassan and Magra varied between 5–10 lakhs. On the other hand, the population of Bhakarwal, Changthangi, Coimbatore, Ganjam, Gurez, Jalauni, Karnah, Kashmir Merino, Kilakarsal, Muzaffarnagri, Poonchi, Pugal, Rampur Bushaire, Shahabadi, Tiruchi black and Vembur of Indian origin and Corridale of exotic origin was less than one lakh. Breeding males across the sheep breeds varied from 269 (Karnah) to 5.44 lakhs (Nellore) and none of them was at risk from view point of breeding male population. Breeding female population in sheep breeds varied from 1,362 (Poonchi) to 41.65 lakh (Nellore). Breeding females in the Karnah and Poonchi breeds were less than 6, 000 and they fall in 'at risk' category. Overall population size of 23 goat breeds of India varied from 10,238 (Attapadi Black) to 174.09 lakhs (Black Bengal). Black Bengal breed of goat emerged as the single largest breed in terms of population size across all the mammalian livestock in India during Breed Survey 2013. Population of breedable females in goat breeds varied from 4,601 (Attapadi Black) to 63.84 lakhs

(Black Bengal). Breeding male population varied from 1,303 (Attapadi Black) to 29.31 lakhs (Black Bengal) across the Indian goat breeds. Therefore, only Attapadi Black goat breed may be classified under the category of 'at risk'.

Most of indigenous pig population was classified as non-descript and only two breeds of Indian origin had been registered so far. These two pig breeds were good in number and were 'not at risk'. A total of six pig breeds of exotic origin are also reared in India, whose overall population size varied from 500 (Saddleback) to 1.76 lakhs (Yorkshire). Though three pig breeds of exotic origin are 'at risk' in India but their sizable population might be available in other countries, so they are not of great concern. These exotic breeds are generally maintained for crossbreeding as per breeding policies of different states of India.

Rate of inbreeding in Indian livestock breeds: The rate of inbreeding estimated for different breeds of cattle was well below 0.5% (needed for a breed 'not at risk') except for Mewati (1.193%), Pullikulam (0.72%) and Vechur (17.893%). The rate of inbreeding in buffalo breeds was also well below 0.5% except in Chilika breed where it was 0.731%. The rate of inbreeding of these breeds may be reduced by increasing the number of breeding males and in Vechur also the breeding females. The rate of inbreeding in all the breeds of sheep (Indian or exotic), goat and pig was estimated to be less than 0.5%. In these species, a good balance of breeding males and females is always expected.

Classification of livestock breeds as per their risk status: Two major criteria for evaluating the risk status of a breed population are demographic (parameter: number of breeding females/males) and genetic (parameter: rate of inbreeding). When assigning populations to risk categories, these two criteria are assumed to be independent, although the genetic and demographic parameters are obviously correlated. High degree of inbreeding accumulated in past may correspond to low current genetic variability in population, therefore, poor fitness and adaptability. Using these principles and the criteria laid down by FAO (2013), the risk status of all the breeds of cattle, buffalo, sheep, goat and pig was analyzed and the risk status of different breeds of Indian Livestock as per Breed Survey 2013 is presented in Table 3. Vechur cattle breed was assessed as critical as the number of its breeding males were less than five and breeding females were 494. Krishna Valley, Mewati, Pullikulam, Punganur cattle breeds were judged as endangered breeds; Mewati on the basis of breeding males and other 3 breeds on the basis of breeding females. Mewati may be categorized as endangered based on the low number of males, even though the number of females qualifies the breed as 'not at risk'. Therefore, this breed is in a high category of risk due to sub-optimal management. By simply increasing the number of males, the breed would fall in the category of'not at risk'. Bargur and Siri cattle breeds were observed to be in vulnerable status of risk based on their breeding female population, which was in the range of 3,000–6,000. All these breeds need immediate attention for their conservation. Chilika and Toda buffalo breeds were assessed as endangered as their breeding female population lied in the range of 300 to 3,000. Among goat breeds of India, only one breed i.e. Attapadi Black is under vulnerable status of risk due to number of its breeding females, which is in the range between 3,000 to 6,000. Two sheep breeds viz. Karnah and Poonchi are in endangered risk status category as their breedable female population was found to be in the range of 300 to 3,000. All these breeds of large and small ruminant need immediate measure of conservation. Three pig breeds of exotic breeds are endangered in India but their sizable population might be available in their native country so they are not

Table 3. Breeds of Indian Livestock at risk as per Breed Survey 2013

Species	Breed	Risk status category	Remarks for such status
Cattle	Bargur	Vulnerable	Breeding females are more than 3,000 but less than 6,000
	Krishna Valley	Endangered	Breeding females are more than 300 but less than 3,000
	Mewati	Endangered	Breeding males are more than five and less than 20 and rate of in breeding is high
	Pullikulam	Endangered	Breeding females are more than 300 but less than 3,000, breeding males are only 25 and rate of inbreeding is high
	Punganur	Endangered	Breeding females are more than 300 but less than 3,000
	Siri	Vulnerable	Breeding females are more than 3,000 but less than 6,000
	Vechur	Critical	Breeding males are less than five, breeding females only 494 and rate of inbreeding is high
Buffalo	Chilika	Endangered	Breeding females are more than 300 but less than 3,000, breeding males are only 25 and rate of inbreeding is high
	Toda	Endangered	Breeding females are more than 300 but less than 3,000
Goat	Attapadi Black	Vulnerable	Breeding females are more than 3,000 but less than 6,000
Sheep	Karnah	Endangered	Breeding females are more than 300 but less than 3,000
	Poonchi	Endangered	Breeding females are more than 300 but less than 3,000
Pig	Australian Large Black	Endangered	Breeding females are more than 100 but less than 1,000
	Duroc	Endangered	Breeding females are more than 100 but less than 1,000
	Saddleback	Endangered	Breeding females are more than 100 but less than 1,000

matter of concern. All the livestock breeds except those categorized in the status of 'at risk' as mentioned above may be categorized as 'not at risk' but they need genetic improvement so as to keep them away from risk in future.

It may be summarized that breed-wise livestock is required in future also so as to further assess the threat to livestock biodiversity in India. All the breed population at risk should be conserved with suitable methodology. It is also important that all the graded animals of different breeds should be graded up for next generations till they become the respective breed. By doing so, the breed population will be further improved. Large number of non-descript animals have been reported in all the five species. This category may be screened to identify some more breeds of livestock. All homogenous populations of different livestock species distributed in different parts of India, presently fall in the category of non-descript but they deserve the status of a breed, must be characterized and registered.

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