GRASSROOTS JOURNALS

Pastures & Pastoralism
Published by The Grassroots Institute
Website: https://grassrootsjournals.org/pp

ISSN 2817-3457 | 02(2024)

M – 00383 | Research Article | Open Access

Validation of the Indigenous Technical Knowledge of Cattle Pastoralists of Andhra Pradesh and Telangana, India

Kanna K. Siripurapu[1*], Faisal Moola[2], Shilpi Sharma[3], Anushree Sainger[4], Kameswara Rao Kotamraju[5]

[1*]School of Arts and Design, Woxsen University, Sangareddy District, Hyderabad - 502 345. India. Email: kanna.siripurapu@gmail.com | ORCID: https://orcid.org/0000-0003-1244-4373
[2]Department of Geography, Environment and Geomatics at the University of Guelph, 50 Stone Road East, Guelph, Ontario, Canada N1G 2W1. Email: fmoola@uoguelph.ca ORCID: https://orcid.org/0000-0001-9803-8514
[3]Telangana State Biodiversity Board, Hyderabad, Telangana, India.
Email: shilpibiodiversity@gmail.com | ORCID: https://orcid.org/0009-0003-2809-7959
[4]MART Global Management Solutions, Sutra Consulting Pvt. Ltd., Bhubaneswar, Odisha, India. Email: anushreesinghvns@gmail.com | ORCID: https://orcid.org/0009-0009-9899-5475
[5]Department of Environmental Sciences, Andhra University, Visakhapatnam, India.
Email: kotamrajukkrao@gmail.com | ORCID: https://orcid.org/0000-0002-5826-9622
**Corresponding author*

How to cite this paper: Siripurapu, K.K., Moola, F., Sharma, S., Sainger, A., & Kotamraju, K.R. (2024). Validation of the Indigenous Technical Knowledge of Cattle Pastoralists of Andhra Pradesh and Telangana, India. *Pastures & Pastoralism*, *02*, 49-81. Doi: https://doi.org/10.33002/pp0204

Received: 14 January 2023
Reviewed: 21 February 2023
Revised: 13 May 2024
Accepted: 15 May 2024
Published: 20 May 2024
Copyright © 2024 by author(s)

Publisher's Note: We stay neutral with regard to jurisdictional claims in published maps, permissions taken by authors and institutional affiliations.

This work is licensed under the Creative Commons Attribution International License (CC BY 4.0).
http://creativecommons.org/licenses/by/4.0/

Open Access

Executive Chief Editor
Dr. Hasrat Arjjumend
Associate Editors
Dr. Arushi Malhotra
Dr. Hongxi Du
This article is edited by Dr. Arushi and Dr. Arjjumend

Abstract

Indigenous technical knowledge (ITK) of livestock breeding is often tacit and not necessarily expressed in conventional forms of scientific research and documentation. Indigenous livestock breeding systems rely mostly on qualitative traits than pure quantitative qualities. Qualitative traits are difficult to measure and most of the indigenous knowledge systems are in forms of qualitative traits. The lack of documentation and predominant qualitative nature makes it difficult to validate the ITK related to livestock breeding. In this context a study was conducted to examine the traditional breeding practices associated with two heritage cattle breeds of the Deccan Plateau region of India. The study examines the criteria used for selection of the breeding bulls of the indigenous Poda Thurpu and Nallmala-Pasa/Kamma, cattle breeds native to the study area. Results of the study identifies fourteen traits specific to breeding bulls and four traits that are generic to the breeding stock/cows. These traits/characteristics are '*deemed desirable*' by the local cattle breeders for the 'heritage breeds', believed to have been bred and managed by them for generations. Observations of the present study supports the notion that traditional breeders of heritage breeds lay more emphasis on qualitative traits (ability to warding-off predators, fending off-springs, coat colour and texture, gait of the animal, temperament, and response and obedience to instructions of the master) than quantitative traits. It was found that local breeders give significant importance to the fertility of bovine bulls than cows. Breeding bulls are meticulously chosen with extreme caution and care, following a very long and meticulous selection process that could last for four years. Traditionally local cattle breeders of the study follow open nucleus breeding system for breeding and are strictly against promotion of inbreeding among their cattle herds. Only men are involved in cattle breeding in the study area and women usually stay away.

Keywords

Heritage breeds, Indigenous cattle, Pastoralists, Deccan Plateau, Indigenous technical knowledge (ITK)

1. Introduction

Heritage breeds,[1] represent the collective knowledge and heritage of the communities they had been associated with. Unlike the wild populations, domestic livestock breeds, especially the Indigenous heritage breeds may have co-evolved with the Indigenous socio-, cultural, economic and ecological systems (LPPS and Köhler-Rollefson, 2005; Siripurapu et al., 2021; Swiderska, 2020). Perhaps, such breeds may survive only when their associated Indigenous systems and indigenous technical knowledge (ITK)[2], is kept intact (Casabianca and Vallerand, 1994; Kohler-Rollefson, and League for Pastoral Peoples, 2003).

ITK of livestock breeding is often 'tacit' and not necessarily expressed in conventional forms, such as scientific research, documentation and publications (ICAR, 2004; Sow and Ranjan, 2021; Slade, and Yoong, 2014). Conventional livestock breeding often focuses only a few quantitative traits, such as the quantity of milk, or pounds of meat produced; on the contrary, ITK of livestock breeding prioritizes a wide range of qualitative traits such as endurance and the ability to walk long distances over difficult terrains (Jaritz et al., 2010), resistance to diseases, warding-off predators, fending off-springs, coat colour and texture, gait of the animal, temperament, and response and obedience to instructions of the master (Dwivedi, 2022; LPPS and Köhler-Rollefson, 2005; Marsoner et al., 2018; Simon et al., 2021; Siripurapu et al., 2020; Tada et al., 2013). Indigenous livestock production systems lay emphasis on minimizing risks rather than maximizing profits (Prakash et al., n.d.).

ITK related to animal husbandry is considered as old as the domestication of livestock itself. Since time immemorial, pastoralists and Indigenous communities have been applying ITK and ethnoveterinary practices (Balaji and Chakravarthy, 2010) to increase milk production, improve fertility, retention of placenta, prolapse, care for the young stock, animal health care (Mir et al., 2020), and preparation of traditional livestock-based products (Devaki and Mathialagan, 2015; Padmakumar, 1998; Rajan and Sethuraman, 1997; Shubeena et al., 2018). Studies on ITK related to livestock management in India are highly concentrated around ethnoveterinary practices and very little information is available on ITK related to bovine breeding. Pastoralists and Indigenous livestock keepers of India have been developing and applying ITK to improve heritage breeds not only to satisfy their own needs but also ensure the survival of such breeds in difficult environmental conditions and terrains. Furthermore, ITK plays a crucial role in conservation of the heritage breeds and the unique animal genetic resources (Jaritz et al., 2010; LPPS and Köhler-Rollefson, 2005; Marsoner et al., 2018; Siripurapu et al., 2020; Siripurapu et al., 2021).

Indigenous communities develop ITK based on their way of life, their day-to-day experiences, improving constantly through experimentation and transferring such knowledge to next generations often through customs, traditions, rituals, folklore, arts, and belief systems (CBD, 2021; ICAR, 2021). ITKs are often adapted according to the local culture and traditions, subsistence, economic needs, and environment. They are very dynamic and continuously changing and evolving in time. The tried and tested ITK pertaining to agriculture, livestock and other allied sectors is often intricately interwoven with the socio-cultural fabric and traditional practices followed by them (ICAR, 2004; Prakash et al., n.d.; Siripurapu and Iyengar, 2023). Similarly, ITK of

[1] According to the Livestock Conservancy, heritage breeds are traditional livestock breeds that were raised by our forefathers, before industrial agriculture became mainstream. These are the breeds of bygone era, which were carefully selected and bred over time and well-adapted to the local environment and the purpose which they were bred for. https://livestockconservancy.org/heritage-breeds/

[2] The ICAR-National Academy of Agricultural Research Management of India elucidates Indigenous Traditional Knowledge (ITK), as the actual application of it in various operations of agriculture and allied sectors. https://naarm.org.in/itk/

livestock breeding is often transferred orally to next generations, through traditions, rituals, beliefs, values, folklore, and cultural practices (Bruchac, 2014; CBD, 2021; Devaki and Mathialagan, 2015; Siripurapu and Iyengar, 2023). Unfortunately, the age old ITK related to animal husbandry, once widely practiced across the country was seldom scientifically studied and documented, consequently, leading to the loss of such valuable information, which is now at the verge of extinction (Borthakur and Singh, 2012; De Amitendu, et al., 2004).

In India, ITK related to agriculture, forestry, fisheries and animal husbandry is as diverse and rich as its unique biodiversity and genetic resources. India has a total livestock population of 536.76 million, comprising of bovine (cattle, buffalo, Drung ox, and yak) population of 303.76 million, sheep 74.26 million, goat 148.89 million, pigs 9.06 million, mithun and yak 0.39 million, horses and ponies 0.34 million, camel 0.25 million, mules and donkeys 0.2 million, stray dogs 10.5 million, and poultry 851.81 million (MoFAHD, 2022). The Indian Council of Agricultural Research - National Bureau of Animal Genetic Resources (ICAR-NBAGR), the nodal agency for the registration of livestock breeds of the country has registered 212 livestock breeds (Shagun, 2023), which includes 20 domestic buffalo breeds, 53 cattle breeds , 37 goat breeds, 44 sheep breeds, 7 horse and pony breeds, 9 camel breeds, 3 dog breeds, 19 chicken breeds, 13 pig breeds, 3 donkey breeds, 1 yak breed, 2 duck breeds, and 1 geese breed (ICAR-NBAGR, 2023). However, about 70 per cent of the total livestock breeds of India still remain non-descript and yet to be registered as defined breeds (Dwivedi, 2022; Ghai, 2022). Except for the crossbreeds, there are hardly any endigenous bovine, camel, equestrian, yak, breeds evolved by the Indian Council of Agriculture Research (ICAR), Institutes of India. It is widely accepted that almost all the livestock breeds (both registered and yet to be registered) of the country are Indigenous and heritage breeds, evolved predominantly by the pastoralists and indigenous livestock keepers of the country, applying ITK.

Traditionally, cattle had been the backbone of Indian agriculture and livestock plays a major role in the economy of the country. In India, livestock sector is an important source of employment and income generation. An estimated 5.51 per cent of the population of the country is directly dependent on it for employment, income and livelihood (DAHD, 2023). It is the primary source of meat, eggs, fibre, hide, draught energy, and dung, besides providing cultural services and performing crucial ecological functions such as nutrient recycling in the traditional penning (Siripurapu, 2023) and in rotational grazing systems still practiced in the country (Dubeux et al., 2007; Dubeux et al., 2009; Haynes and Williams, 1993; Silveira, et al., 2013; Sollenberger, et al., 2002). Livestock contributes to 30.87 per cent of the total agricultural and allied sector Gross Value Added (GVA) and accounts to 6.17 per cent of the total GVA of India (DAHD, 2023; NSO, 2022). The unaccounted value of draught animal energy (DAE) in India is estimated at ₹75 – 95 Crores, (US$ 14 – 17.5 million) a day (Singh and Singh, 2021; Phaniraja and Panchasara, 2009). If both the unaccounted dung and draught energy economy are also added, the GVA of the Indian livestock sector could be much higher than the estimated value (Natarajan et al., 2016; Siripurapu, 2022; Siripurapu, 2023).

Usually the males of cattle, buffalo, camel, horses, yak, etc. are used for DAE purpose in India. However, oxen of the Indian Zebu cattle (*Bos indicus*) breeds remain the mainstay of DAE in the country (Manomohan et al., 2021; Natarajan et al., 2016). The Indian Zebu cattle breeds can be classified into three major types: draught purpose, dairy purpose and dual-purpose breeds. Manomohan et al. (2021) observes that dairy and dual-purpose cattle breeds are predominantly distributed in North and North-Western India, and draught purpose cattle breeds are predominantly distributed in Southern and Eastern India. South India is home to diverse, draught purpose zebu cattle breeds of different shapes and sizes: Vechur and Punganur (dwarf size), Hallikar, Bargur, Poda Thurpu (compact size), Umbalchery, Pulikulam, (medium size), and Ongloe, Deoni, Kangayam (large size) (Manomohan et al., 2021). It is widely accepted

that diversity of the Indian Zebu cattle breeds is the product of ITK of the traditional pastoralists and livestock keepers of India.

Breeding bulls are extremely important in the DAE, dairy, and beef industry; however, Butler et al. (2020) points out that in the conventional bovine breeding research and programmes, female bovine fertility is given significant attention, and the improvement of breeding bulls has not received the same. Conventionally, female bovine fertility is enhanced through advanced technologies like the improved assisted reproductive technologies, genetic selection, semen, and embryo sexing, among others, but the same is not true for breeding bulls (Bora, 2022; Quelhas et al., 2021). On the contrary, traditional pastoralists and livestock keepers in India are found to lay emphasis on breeding bulls than cows (Siripurapu et al., 2020).

A cross-sectional study was conducted on the ITK related to bovine breeding, in the background of the lack of adequate scientific documentation of ITK related to livestock breeding, prevalence of the notion that traditional animal husbandry practices are unscientific and backward among the mainstream academia and scientific communities. The study assumes significance in the context of the widespread notion that indigenous and heritage livestock breeds are inferior to the exotic and crossbreeds. And the dwindling populations of the Indigenous livestock breeds, and the lack of focus on the improvement of fertility of bovine breeding bulls in the conventional bovine breeding research programmes in India.

The objective of the present study is to examine the traditional breeding practices of associated with the heritage cattle breeds in the study area. The study examines the criteria used by pastoralists of the study area for selection and management of breeding bulls of heritage cattle breeds. For this purpose, ITK related to breeding and management of two Indigenous cattle breeds, Poda Thurpu (Siripuapu et al., 2019a) and Nallmala-Pasa/Kamma (Siripurapu et al., 2019b), native to the Deccan Plateau region of India (also the study area), was investigated and the results are presented as follows.

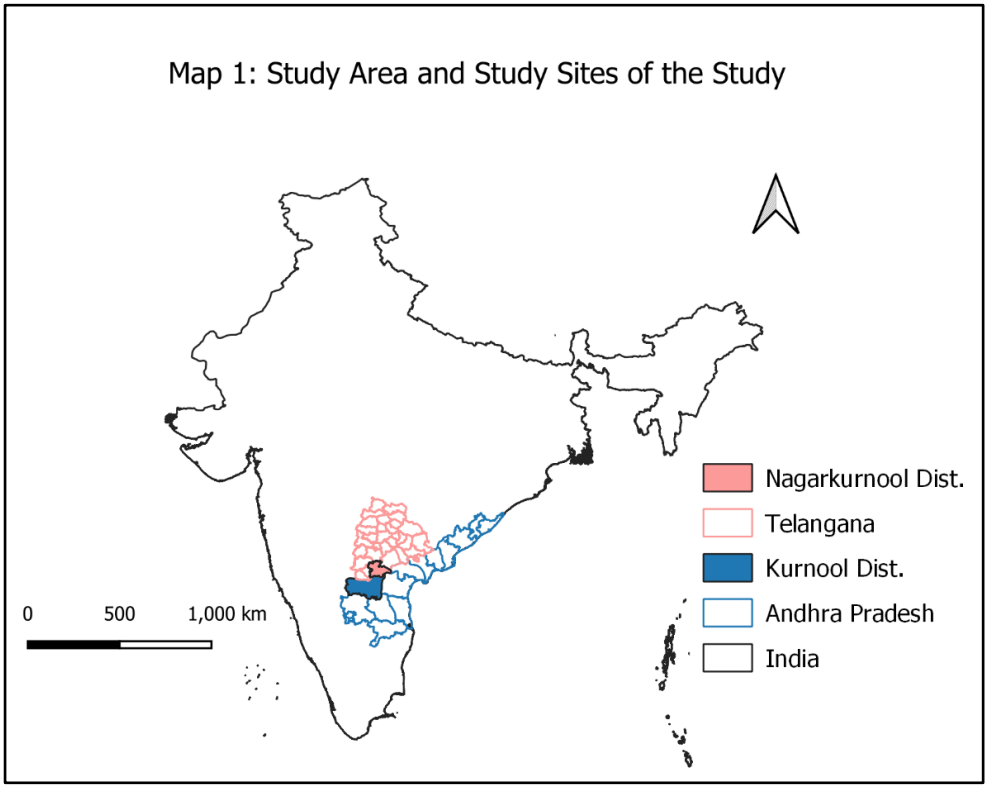
2. Methodology

2.1 Study Area

South India is known for the presence of diverse draught energy and dual-purpose Indigenous Zebu cattle breeds. It is also home to many traditional pastoralists belonging to the Kuruma, Kuruba, Golla, Lambadi, Sugali, Toda, and Konar ethnic communities (Sharma et al., 2003; Siripurapu et al., 2020). Based on the aforementioned information, two South Indian states of Andhra Pradesh (AP) and Telangana are selected as the study area. The study area is geographically located in the Deccan plateau region of India. Topography of the study area is highly undulating and hilly, covered in dry mixed deciduous forests and tall grasses. Nagarkurnool district of Telangana and Kurnool district of Andhra Pradesh are designated as the study sites of the present study (Figure 1).

Nagarkurnool district is located at 16.4833°N 78.3333°E, at an elevation of 458 m. It has an area of 6,924 km^2, comprising of 358 villages (including inhabited hamlets) and a total population of 861,766 (Telangana Government, 2019). Nagarkurnool district experiences a hot savannah type climate with the average summer temperature of 42°C. Kurnool district is located 15.6443° N, 78.1108° E, at an elevation of 273 m. It has an area of 17,658 km^2, comprising of 921 villages and a total population of 4,053,463 (Andhra Pradesh Government, 2019). Kurnool experiences a hot savannah climate, with summer temperatures ranging from 26°C – 46°C. The entire study area falls under the scarce rainfall zones of India and receives an average annual rainfall of 500-750 mm. Agro-

ecologically, it is located in the Deccan Plateau, hot arid eco-region and agro-climatically it is located in the Southern Plateau and hills region (Venkateswarlu et al., 2011).



.Figure 1: Map of the Study Area and Study Sites of the Present Study

2.2 The Cattle Breeds Selected for the Present Study

During the period 2016-19, a rapid survey and reconnaissance study (Holtzman, 1986) was conducted by the Watershed Support Services and Activities Network (WASSAN), a non-profit based out of Hyderabad city, Telangana, for the identification of yet to be descript populations of Indigenous cattle breeds in the study area. The objective of the survey was to identify and characterize the non-descript Indigenous cattle populations and register them as defined breeds with the ICAR-NBAGR. The survey led to the identification of two Indigenous cattle populations of Poda Thurpu in Telangana state (Siripurapu et al., 2019a) and Nallamala-Pasa/Kamma cattle population in AP (Siripurapu et al., 2019b). Both the identified cattle populations are found to be draught energy purpose breeds and are used extensively for draught purposes across the South Indian states of Karnataka, Telangana and AP. The native breeding tract of Poda Thurpu and Nallamala-Pasa /Kamma cattle are Nagarkurnool and Kurnool districts, respectively. The population of Poda Thurpu cattle breed is found in 27 villages, across 4 mandals of Nagarkurnool district of Telangana. The population of Nallamala-Pasa/Kamma cattle is found in 34 villages, across 6 mandals of Kurnool district of AP.

Poda Thurpu made history in 2021 when it was registered as a defined Indigenous draught power and heritage cattle breed with the ICAR-NBAGR, (Accession number INDIA_CATTLE_3600_PODATHURPU_03044), (ICAR-NBAGR, 2022). The hardy breed is very popular among the farmers of Telangana as well as the neighbouring states of Karnataka and Andhra Pradesh. Oxen of this breed are famous for excellent draught power and their ability to work both in dry (cotton farms) and wet (inundated paddy farms) agricultural operations. A state level breed survey conducted in 2016-17 by WASSAN, a national level non-profit based in Hyderabad city, Telangana, suggests that around 2500 - 3000 male calves/bullocks, worth USD 0.3 – 0.5 million are sold every

year in its native breeding tract. The annual economy of Poda Thurpu cattle in the state is estimated at USD 1.8 – 2.4 million. The estimated total population of the breed is 15,000 individuals, confined to a very small geographic area, which makes the breed extremely vulnerable to genetic erosion, decimation from disease outbreaks, among others. The breed is traditionally maintained as a nucleus herd under extensive mobile pastoral systems. Breeders sell dung to farmers and practice the traditional penning system (Siripurapu, 2023), accounting to the second most important household income, next to the sale of live animals for draught purposes. The traditional breeders of the breed have registered themselves into an association named "Amrabad Poda Lakshmi Govu Sangham (APLGS)". The registration was facilitated by WASSAN with the grants from the Global Environment Facility (GEF) and Telangana State Biodiversity Board, Telangana. Further, documentation of biocultural diversity (Siripurapu and Iyengar, 2023) and ITK associated with the breed helped APLGS to win the coveted India Biodiversity Awards 2021 for conservation of Domesticated Indigenous/Local Species.

Photo 1: Breeding Bull of Poda Thurpu Cattle Breed (Photo credit: Chandrasekhar Nemani, WASSAN)

The Nallamala-Pasa/Kamma cattle is a medium sized, zebu cattle breed, belonging to the draught energy group. The populations predominantly have white coat. Oxen of this cattle population are famous for their excellent draught power and hard hooves. Oxen of this cattle can work for an average 7.5 hours a day, under harsh weather and field conditions. A pair of bullocks (4 yr old) of Nallamala-Kamma cattle could cost anywhere between USD 721–841, at the local market. Oxen are usually leased to farmers for agriculture operations for a fee of USD 30/day. Cows are very poor milk yielders, (1.23 litres/milking), therefore, not preferred for dairy production. A state level breed survey conducted by WASSAN, during 2018-19, suggests that approximately 7,248 breeding animals are found in the native breeding tract. Similar to the other study cattle breed, Nallamala-Pasa/Kamma cattle are also maintained under nucleus herd system. Significant number of the non-breeding population (only bullocks) of the cattle population has been reported from few districts in the neighbouring Telangana state. Traditionally, the herds of this cattle are managed under extensive pastoral system. Breeders are also involved in the sale of dung to farmers, accounting to the second important source of household income, next to the sale of life animals for draught purposes. The traditional breeders of the cattle have been registered into an association named "Nallamal-Kamma Govu Sangham (NKGS)". The

registration was facilitated by WASSAN with the grants from ICAR-NBAGR. The registration of Nallamala-Pasa/Kamma cattle population as a defined breed is in progress. At the moment it was unclear whether the cattle population will be registered as 'Nallamala-Pasa' or 'Nallamala-Kamma' cattle. Therefore, the cattle population is referred as Nallamala-Pasa/Kamma in this article.

Photo 2: Breeding Bull of Nallamala-Pasa/Kamma Cattle Breed, (Image credit: Megavardhan Reddy Pothula, WASSAN)

Both Poda Thurpu and Nallamala-Pasa/Kamma cattle breeds are primarily used for draught energy purposes in their respective native breeding tracts. Farmers in the study area believe that hooves of these breeds are harder than other similar breeds, therefore, less susceptible to infections. Gelded bulls of these breeds are widely used for wet (inundated paddy fields) and dry (cotton, millets, peanuts) agriculture operations, as well as off-farm activities (threshing and carting). Oxen of these breeds are known for endurance, agility, and tolerance to extreme temperatures (Siripurapu et al., 2019a; Siripurapu et al., 2019b). Cows of both the breeds are poor milk yielders, therefore, not preferred for dairy purposes.

Traditionally, herds of both the breeds are used for penning in exchange for a fee and food grains, to improve soil fertility of farmlands in the study area (Siripurapu, 2023). Besides penning, cattle dung is also sold to farmers by the pastoralists and livestock keepers in the study area. Sale of live animals (male calves for draught energy purposes), and dung economy (penning and sale of dung), are the primary and secondary sources of household income of pastoralists in the study area, respectively (Siripurapu et al., 2020).

2.3 The Traditional Cattle Breeders of the Study Area

The rapid survey and reconnaissance study resulted in the identification of a total 204 traditional cattle breeds in the study area. Out of which, 101 are Poda Thurpu cattle breeders and 103 are breeders of the Nallamala-Pasa/Kamma cattle breed. The Poda Thurpu cattle breeders inhabit 27 villages across 4 mandals of Nagarkurnool district of Telangana. Traditional breeders of Poda Thurpu cattle predominantly belong to Golla, and Lambadi pastoralist communities. Nallamala-Pasa/Kamma cattle breeders reside

in 34 villages, across 6 mandals of Kurnool district of AP. The dominant communities breeding and managing Nallamala-Pasa/Kamma cattle are Jangala, Sugali and Golla communities. The Golla and Jangala communities belong to the other backward caste (OBC), and both the Lambadi and Sugali communities, also known as Banjara, a notified nomadic tribe, by the National Commission for Scheduled Tribes of India. Traditionally, all the dominant communities of the present study are pastoralist communities and lead a semi-nomadic lifestyle, traversing across the Deccan Plateau region along with their livestock and cattle herds (Siripurapu et al., 2020).

2.4 Materials and Methods

Out of the 204 traditional cattle breeders identified through the rapid and reconnaissance study, only 86 cattle breeders (45 Poda Thurpu and 41 Nallamala-Pasa/Kamma), were available and agreed to participate in the present study. The main reasons for their unavailability are seasonal migration and remoteness. Traditional cattle breeders of both the cattle breeds practice seasonal migration from November to June (Siripurapu et al., 2020). For almost half of the year (July to October), they graze their cattle herds among the customary grazing pastures located inside the Nallamala forest. Such customary grazing pastures often remain inaccessible due to their remote location inside the Nallamala forest, making it difficult to establish contact with pastoralists for data collection.

Primary data related to traditional cattle breeding practices of the pastoralists was collected through personal interviews and focused group discussions (FGDs). A total 12 FGDs (7 Poda Thurpu cattle breeders and 5 Nallamala-Pasa/Kamma cattle breeders), consisting of 5-7 participants was conducted for this purpose. In addition to the FGDs, 27 personal interviews (15 Poda Thurpu and 12) were conducted for collection and triangulation of the primary data. Prior oral consent of the study participants was taken before data collection. Almost all the 86 pastoralists participated in the FGDs and personal interviews were men and women did not show any interest to participate in the interviews for multiple reasons: traditionally, cattle pastoralist women of the study area are not associated with cattle breeding and it is purely men's domain; women are highly associated with nurturing the young calves, and injured and sick animals; women are not comfortable discussing about cattle breeding, especially when the interviewer/researcher is a man. In cases when women joined the FGDs, they simply walked out when they realized that the focus of the interview was cattle breeding.

Open ended questions like, "do you practice artificial insemination, why; why not?", "how do you select the breeding stock?", "what is more important, cow or bull, for breeding?", "how is the breeding bull selected?", "what are the traits of a breeding bull?", were asked during the interviews and FGDs. Primary data collected was predominantly qualitative in nature. During the interviews, it was noticed that traditional cattle breeders attach the highest importance to the selection and management of the breeding bulls. Conducting FGDs and personal interviews was stopped at the point of achieving data saturation, when no further new data was produced (Cresswell, 2013).

The data collected through personal interviews and FGDs was predominantly qualitative in nature. Interviews were captured through audio recordings and field notes. The recorded information was transcribed into Microsoft Word document and subjected to further analysis. Transcripts were manually coded (Strauss, 1987), adopting the inductive coding process (Leech and Onwuegbuzie, 2007). Inductive coding not only helped in breaking the data into chunks, but also allowed the codes to emerge naturally from the data itself. Codes such as the size and shape of the head of the cattle, gait of the animal, hair whorls on the body, size of the tail, coat colour, temperament, and behaviour of the animal, etc. have emerged naturally from the data itself (Fereday andMuir-Cochrane, 2006; Leech and Onwuegbuzie, 2007). The list of

codes was entered into an excel sheet and a matrix was generated for all the 86 transcripts for identification of the 'shared beliefs' (i.e. same code mentioned by two or more participants) (Francis et al., 2010). The presence/absence and the frequency of occurrence of shared beliefs was used to arrive at data saturation. Inductive coding of the shared beliefs has resulted in the identification of 14 codes (broad criteria adopted by the traditional cattle breeders) related to the selection of breeding bulls (Table 1).

Table 1: The Traits Used by Traditional Cattle Breeders for the Selection of Breeding Bulls in the Study Area

S.No.	*Codes Identified for Selection of Breeding Bulls of Poda Thurpu Cattle*	*Codes Identified for Selection of Breeding Bulls of Nallamala-Pasa/Kamma Cattle*
1.	Size of the head (length and width)	Size of the head (length and width)
2.	Shape of the forehead	--
3.	Number and position of hair whorls on the body	Number and position of hair whorls on the body
4.	Nature of the hooves (hard/soft)	Nature of the hooves (hard/soft)
5.	Colour of the hooves	--
6.	Length of the tail	--
7.	Gait of the animal (strut/drag)	Gait of the animal (strut/drag)
8.	Shape of the legs	Shape of the legs
9.	Colour of the horns	Colour of the horns
10.	Shape and orientation of the horns	Shape and orientation of the horns
11.	Coat colour	Coat colour
12.	--	Height of the animal
13.	Temperament and response of the animal to instructions	Temperament and response of the animal to instructions
14.	Duration of the observation	Duration of the observation

Inductive coding has also resulted in generating 4 codes (broad criteria used by traditional cattle breeders) with regards to retention of female breeding stock in the herd (Table 2). These codes formed the basis for further data collection and analysis to validate ITK. The participant cattle breeders were asked to choose codes (traits) that are perceived very important to them and are also quantifiable. The breeders of Poda Thurpu cattle chose colour of the coat, horns and hooves and orientation of the horns as the most important traits. And the breeders of Nallamala-Pasa/Kamma cattle chose height and coat colour as important. It was assumed that traits that were '*deemed desirable*' by the traditional cattle breeders are transposed upon the respective cattle populations employing ITK. To validate our assumption, however, biometric data of the study cattle populations was collected for further investigation and analysis.

Table 2: The -Traits Used by Traditional Cattle Breeders for Retention of Female Breeding Stock in the Study Area

S.No.	*Codes Identified for Retention of Female Breeding Stock of Poda Thurpu Cattle*	*Codes Identified for Retention of Female Breeding Stock of Nallamala-Pasa/Kamma Cattle*
1.	Number and position of hair whorls on the body	Number and position of hair whorls on the body
2.	Colour of the hooves	--
3.	Coat colour	Coat colour
4.	--	Height of the animal

Based on the codes (14 for breeding bulls and 4 for breeding stock/cows), pertinent biometry data (coat colour, size, shape and colour of horns, head size, body size) of the study cattle population was collected from a sample of 595 adult (above 4 years old) animals (303 Poda Thurpu cattle and 292 Nallamala-Pasa/Kamma cattle). Out of the

total 595 cattle sampled, 196 are breeding bulls (101 Poda Thurpu and 95 Nallamala-Pasa/Kamma cattle), and the remaining 399 are cows (202 Poda Thurpu and 197 Nallamala-Pasa/Kamma).

Biometry data of the study cattle was deemed as empirical evidence to support our assumptions. The purpose of collecting biometry data is to check whether the study cattle population possess the traits 'deemed desirable' by the traditional cattle breeders. However, 57 per cent of the codes generated are qualitative in nature. For instance, traditional breeders' preferences for temperament and obedience to instructions, nature of the hooves, colour of the coat, and hooves, and shape of the horns were qualitative in nature (Table 3). So, proxy biometry (numerical) data was collected to measure the codes that are qualitative in nature. For instance, number of animals that have preferred coat colour, horns, etc were counted and recorded for analysis.

Table 3: Nature of the Traits Used by Traditional Cattle Breeders for the Selection of Breeding Bulls in the Study Area

S.No.	*Qualitative traits*
1.	Nature of the hooves (hard/soft)
2.	Colour of the hooves
3.	Gait of the animal (strut/drag)
4.	Shape of the legs
5.	Colour of the horns
6.	Shape and orientation of the horns
7.	Coat colour
8.	Temperament and response of the animal to instructions
	Quantifiable traits
9.	Height of the animal
10.	Size of the head (length and width)
11.	Shape of the Forehead
12.	Number and position of hair whorls on the body
13.	Length of the tail
14.	Duration of the observation

For the purpose of biometry data collection, the questionnaire 'breed descriptor for registration' prescribed by the ICAR-NBAGR, was adopted (ICAR-NBAGR, 2010). Biometry of adult animals was analysed against the codes generated through inductive coding. The frequency of occurrence of each code was calculated from the biometry data. For instance, the frequency of codes like the desired colour of the coat, colour the hooves, and the colour and orientation of horns among Poda Thurpu cattle population was calculated from the biometry data. Similarly, the frequency of codes such as the desired height and coat colour among Nallamala-Pasa/Kamma cattle was calculated. The presence of a desired trait (code) and the frequency of its occurrence among the study cattle population was deemed as the proxy indicator of the ITK of traditional cattle breeders of the study.

To validate our assumption, however, this study adopted the QuIK (Quantification of indigenous knowledge) method (De Villiers, 1996). The basic principle of this method was that local communities know and understand the environment in which they live and answers for many questions can be found in the collective knowledge and experience of the community, livestock breeders in the present context. Therefore, traditional livestock keepers perceived to be experts in a particular ITK was consulted for triangulation and validation of the results, and confirmed by them (De Amitendu et al., 2004; Mahto, 2012). During the QuIK, triangulation process, the authors have also learned about a simple but an effective traditional measurement technique used by the breeders of Nallamala-Pasa/kamma cattle to measure and maintain the height of the

animals. Cattle breeders use the terms "*Padigi Aavu*" and "*Aidu Jaanala Aavu*", referring to cattle that are believed to be suitable for life in hilly and undulating terrains covered in forests and usually experiences extreme temperatures. The terms "*Padigi Aavu*" and "*Aidu Jaanala Aavu*", and the traditional height measuring techniques are discussed in detail in table (4).

Table 4: Traditional Techniques for Measuring and Maintaining the Height of the Cattle

S.No.	*Type of Animal by Height (Local Name)*	*Indigenous Unit of Measurement*	*Unit in Inches*	*Traditional Height Measuring Technique*
1.	*Padigi Aavu*	Forearm	18 inches	Local communities use just a baton and forearm to measure height of the animal. The length of a forearm (elbow to fingertip) is called locally as "mora" which is approximately 1.5 feet (18 inch). The animal should be approximately 4 inches less to three mora or 4.5 feet (137.16 cm). Any animal which stands more than the desired height will be eliminated from the herd as it is unsuitable for life in the hillocks and high temperatures. Results of the study suggests that the average height of Nallamala-Kamma cow is 126.58 cm / 4.15 ft and the breeding bull is 135.82 cm / 4.45 ft.
2	*Aidu Zaanala Aavu*	Hands high	4 inches	Local communities also keep smaller size cattle (approximately 3.5 feet in height), known locally as "*Buddaaavu*". The other indigenous technique which is used to select *Buddaaavu* is by using the length of a hand (tip of the little finger to the tip of the thumb) known locally as "*Zaana*". A baton is used for a ruler. Ideally, the animal should be *aidu* (five) *zaanalu* tall to qualify for a *Buddaaavu* and any animal either short or tall are eliminated from the herd.

3. Results and Discussion

Inductive coding (Leech and Onwuegbuzie, 2007) of the transcripts has generated 14 codes specific to breeding bulls and 4 codes generic to the breeding stock/cows. These codes are the traits or characteristics '*deemed desirable*' for the 'heritage cattle breeds' managed by the traditional cattle breeders participated in the study. Biometry data of the cattle related to the codes was collected and analysed. The frequency of occurrence of each code was considered as the proxy evidence to support our assumption that the study cattle populations possess the traits deemed desirable by the cattle breeders. And such traits are transposed on to the cattle populations of the study through the application of ITK. The results of the study are presented in this section.

Traditionally, both Poda Thurpu and Nallamala-Pasa/Kamma cattle are managed under 'nucleus herd system' and breeders strictly follow 100 per cent natural servicing. The average herd size of Poda Thurpu and Nallamal-Pasa/Kamma cattle is 45 and 72, respectively. Cattle breeders of both the study cattle populations practice selective breeding to maintain high genetic purity, and preferred physical traits such as the desired coat colour, orientation of horns, size of the animal, and temperament.

One of the important traits breeders of Poda Thurpu cattle look for in the breeding bull is the size (length and width), and shape of the head. Local breeders describe it as 'large and prominent' and the biometry data analysis suggests that the average head size of the breeding bull are 43.74 and 20.17 cm, respectively. A convex shaped forehead with a deep furrow in the centre is considered desirable by the breeders. It was found that 100 per cent of the breeding bulls have convex shaped foreheads with deep furrows in the centre (Table 5).

The number and location position of hair whorls (cowlicks) on the animal's body is an extremely important characteristic to the participant cattle breeders. Breeders associate the number and location of the hair whorls with fertility and virulence of the breeding bull. Breeders of Poda Thurpu cattle prefer breeding bulls with a single hair whorl on the forehead and another whorl on the back, right behind the hump. Breeders do not prefer breeding bulls with two coexisting hair whorls on any part of the animal. Breeders also do not prefer animals with hair whorls over the tailbone for breeding (Table 5).

Similarly, the breeders of Nallamala-Pasa/Kamma cattle also are emphatic on the shape, location and number of hair whorls. However, it was found that breeders of Nallamala-Pasa/Kamma cattle have a more elaborate vocabulary and description of hair whorls than their Poda Thurpu cattle breeder counterparts. The Nallamala-Pasa/Kamma cattle breeders distinguish hair whorls based on their location on the animal's body and ascribe different qualities to each (Table 6). They distinguish location of the hair whorls on three distinct locations, the back (on the spine), the dewlap, and the forehead. The description of the qualities of hair whorl based on their location on the animal's body are as follow:

Hair whorl on the back (on the spine):
i). *Dhanaraasi sudi* (Wealth hair whorl) is a single hair whorl located on top of the hump, and the animal with such a hair whorl is considered healthy and brings good luck to the master. Breeding bulls with Dhanaraasi sudi are highly priced and are in demand. ii). Paataala sudi, is a single hair whorl located at the base of the hump towards the posterior side is considered second best to Dhanaraasi sudi. iii). Maamolu sudi (common hair whorl) is a single hair whorl located 4 inches away from the place of Paataala sudi towards the posterior side. iv). Dabbodu sudi, is a single hair whorl present close to the tail bone. v). Poraka sudi, is a single hair whorl present on the tail bone. And vi). Toda giri sudi, (hair whorl on the thigh) is the single hair whorl present over tail at thigh region.

Hair whorl on the dewlap:
i). Potu sudi is the single hair whorl present on the left side of the dewlap. It is considered that a bull with Potu sudi is extremely virulent. ii). The bull with a hair whorl one on each side of the dewlap is considered good. And iii). The bull with hair whorl only on the right side is considered unfit.

Hair whorl on the forehead:
i). Manchi sudi, is the single hair whorl present right at the center of the forehead. It is considered good. And ii). Kumpati sudi, is the hair whorl present towards the muzzle.

The number and location of cowlicks is associated with good or bad luck to the master's family and the master. Any animal with an undesirable number or position of hair whorl is usually rejected by the breeders and the local people to avoid a potential bad luck. Breeders' preference for animals with a certain shape, number and location of hair whorls may have some scientific legitimacy and is not entirely baseless. Studies found an association between shape and position of hair whorls with genes, heredity, cognisance, temperament, brain development, health conditions and sexuality, in cattle (Craft and Warner, 1934; Deesing, 2020), dogs (Lillebo, 2014; Tomkins and McGreevy, 2010), horses (Cruz et al., 2021; Encina et al., 2023), swine (Craft and Warner, 1934) and human beings (Aksu et al., 2013; Csabi et al., 2014; Kiil, 1948; Klar, 2005; Luo et al., 2023; McDonald, 2011; Ruiz-Maldonado, 2002; Sechi, et al., 2020; Smith and Gong, 1973; Smith and Gong, 1974; Tirosh et al., 1987). Studies found that cattle with hair whorls above the eyes are more agitated during restraint (Grandin et al., 1995), and in the auction ring (Lanier et al., 2001). Broucek et al. (2004) reports an association of hair whorl position and learning ability and locomotor behaviour in cattle. Aierqing et al. (2020) found a relationship between the location of the hair whorl and the animal's adaptability, obedience, and excitability. Couse (2015) reports that bulls with a round hair whorl between their eyes are more likely to produce high quality sperm than bulls without the same. Scientific studies related to hair whorls in cattle are highly concentrated on hair whorls located on the head and not many studies have focused on hair whorls found on other body parts.

Cattle breeders of both the study cattle breeds prefer animals with hooves that are hard, thick, large, and firmly held together, and not be split wide and loose (Table 5 & 6). Poda Thurpu cattle breeders prefer breeding bulls that have copper brown colour horns and hooves and Nallamala-Pasa/Kamma, cattle breeders have a preference for breeding bulls that have slate coloured horns and hooves. Breeders of both the study cattle breeds are very particular about the shape of the legs and gait of the breeding bulls. They prefer bulls with thick and stout fore and hind legs, and with their knees not touching each other. Strides of the animal should be composed, firm and not wobbly. Strides of the animal should resemble a trot, lifting the feet high off the ground and step down firmly, as if rocks would get crushed under its feet. The animal should not stagger or drag its feet.

Breeders of Poda Thurpu prefer bulls with short and lean tails with the tail switch ending just above the knees, a short tail is a symbol of agility in breeding bulls. However, such preference was not observed among Nallamala-Pasa/Kamma cattle breeders. Poda Thurpu cattle breeders show preference for bulls with strong and upward curved horns pointing forward. Breeders of Nallamala-Pasa/Kamma cattle are fond of bulls with short and strong horns that are wide at the base. Breeders of both the breeds show an extremely strong and different preferences when it comes to coat colour. Poda Thurpu cattle breeders show very strong affinity for breeding bulls with chocolate brown blotches/speckles on a white coat. Breeders prefer animals to have chocolate brown blotches/speckles on cheeks and shoulders. Correspondingly, 93.26 per cent of breeding bulls and 88.2 percent of cows of Poda Thurpu cattle are found to have brown blotches/speckles on a white coat. On the contrary, breeders of Nallamala-Pasa/Kamma cattle prefers milky white coat colour. The word '*Pasa*' means 'white' in

Telugu, a regional language in India. Correspondingly, 97 per cent of breeding bulls and 89 per cent of cows of Nallamala-Pasa/Kamma cattle have a white coat (Table 5 & 6).

Height of the animal is one of the characteristics breeders of the study cattle populations are very particular about. Although, height preference was a pronounced trait among Nallamala-Pasa/Kamma cattle breeders than breeders of Poda Thurpu cattle. Both the study cattle breeds are medium-compact size breeds, suitable for life in undulating, hilly, and semi-arid geographies (Siripurapu et al., 2019a; Siripurapu et al., 2019b). The average height of a Poda Thurpu cattle bull and cow is 119.38 and 111.84 cm, respectively. Similarly, the average height of a Nallamala-Pasa/Kamma bull and cow is 135.82 and 126.58 cm, respectively. Nallamala-Kamma cattle population is referred to locally as *Padigi Aavu* because of its 'specific height' (4.5 ft / 137.16 cm) and size. Breeders of Nallamala-Pasa/Kamma cattle say that it is necessary to maintain a specific height and body size to enable the animal to tolerate heat and thrive in undulating, hilly terrains experiencing semi-arid and harsh weather conditions. Breeders rely on ITK to maintain the desired height among the cattle population. They deploy a very simple and easily accessible, yet effective indigenous technique to achieve this. Breeders use their forearm and hands high measurement techniques to measure the height of animals (Table 4). Using this indigenous technique breeder retains only "*Padigi Aavu*" and "*Aidu Jaanala Aavu*" (approx. 3.5 ft height), believed to be suitable for life in the local environment, which is often harsh and unforgiving.

Cattle breeding is the domain of men among the participant communities of the study. In general women do not interfere in cattle breeding in the study area. Breeding bull selection is a very meticulous and time-consuming process, which may take between 2-4 years of careful observation, scrutiny, and care for the animal. Bulls are available for servicing when they are about 46 and 41 months old in Poda Thurpu and Nallamala-Pasa/Kamma cattle respectively (Siripurapu et al., 2019a, 2019b). Breeders of Nallamala-Pasa/Kamma cattle only prefer male calves born in the 2–3 pregnancies for breeding bulls. Breeders say that cattle, similar to humans, are neither physically nor mentally prepared for motherhood during their first pregnancy (Table 5 & 6). Also, breeders believe that cows often lose virulence post their third pregnancy, and they usually give birth to inferior calves, therefore, a male calf born after the third pregnancy is not preferred for breeding.

Table 5: The Criteria Used by Traditional Cattle Breeders Breeding of Poda Thurpu Cattle in the Study Area

S.No.	*Codes Generated for Poda Thurpu Cattle*	*Traditionally Deemed Desired Traits*	*Occurrence among Breeding Bulls (n = 101)*	*Occurrence among Cows (n = 202)*
1.	Size of the head (length and width)	Large and prominent	Average length: 43.74 & Width: 20.17 cm	Average length: 41.72 & width: 18.45 cm
2.	Shape of the Forehead	Convex with a deep furrow in the centre	100 %	NA
3.	Number and position of hair whorls on the body	Should have single hair whorl on the forehead and one on the back, right behind the hump. There should not be two hair whorls together and	---	---

S.No.	*Codes Generated for Poda Thurpu Cattle*	*Traditionally Deemed Desired Traits*	*Occurrence among Breeding Bulls (n = 101)*	*Occurrence among Cows (n = 202)*
		there should not be any hair whorls over the tailbone.		
4.	Nature of the hooves	Should be hard, thick, large, and firmly together, should not be split wide, and should not be loose	---	NA
5.	Colour of the hooves	The colour should be copper brown.	Copper brown colour (91.01%)	Copper brown colour (89.20%)
6.	Length of the tail	Should be lean and end above the knees – symbol of agility.	Average length: 119.17 cm	Average length: 113.12 cm
7.	Gait of the animal	Strides should be composed and firm. The stride should resemble a trot, lifting the feet off the ground and stepping firmly back, as if rocks would be crushed under the feet. There should not be any staggering or dragging of feet.		NA
8.	Shape of the legs	Should be thick and stout, and knees should not touch each other.		NA
9.	Colour of the horns	Should be copper brown in colour.	Copper brown colour (93.26%)	Copper brown colour (85.23%)
10.	Shape and orientation of the horns	Should be strong, curved, and pointed forward (esp. for breeding bulls)	Forward: 28.09% Upward: 29.21%	NA
11.	Coat colour	Brown speckles on a white coat (speckles should be on the cheeks and shoulders)	93.26%	88.2%

S.No.	*Codes Generated for Poda Thurpu Cattle*	*Traditionally Deemed Desired Traits*	*Occurrence among Breeding Bulls (n = 101)*	*Occurrence among Cows (n = 202)*
12.	Temperament and response of the animal to instructions	Breeding bull should respond to the instructions of its care taker. It should play a major role in maintaining and protecting the herd. Breeding bulls are expected to lead the herd, warn / alert and protect the herd from predators and other dangers.		
13.	Duration of the observation	0 - 4 years	Calves selected for breeding purposes are kept under observation for 4 years. It is allowed to mate and its progeny is observed for one generation. The bull will be retained if calves born to it exhibit the desired qualities (coat, hooves and horn colour). Else, it is gelded and sold or used for draught purposes.	NA
14.	Height of the animal		Average Height: 119.38 cm	Average Height: 111.84 cm

The breeding bulls are kept within the herd for about 10 years, till they pass their prime. Bulls that are past their prime are permanently separated from the herd, used for draft purposes or allowed to grow old naturally, with care, and never slaughtered. One of the highly valued traits in a breeding bull is its temperament and response to the instructions of the master. Breeders of both the study cattle breeds believe that a breeding bull is more than a breeding machine, it plays a major role in leading, maintaining, defending and protecting the herd from predators and other dangers. A breeding bull is expected to be aggressive, but also respond and obey to the instructions of the master (Table 5 & 6). Breeders of Nallamala-Pasa/Kamma cattle believe that a ring forms on cow's horns every time it calves. And said that it is possible to guess the number of times the cow calved by counting the rings on its horns.

Table 6: The Criteria Used by Traditional Cattle Breeders for Breeding of Nallamala-Pasa/Kamma Cattle in the Study Area

S.No.	*Codes Generated for Nallamala-Pasa/Kamma Cattle*	*Traditionally Deemed Desired Traits*	*Occurrence among Breeding Bulls (n = 95)*	*Occurrence among Cows (n = 197)*
1.	Size of the head (length and width)	Large and heavy	Average length: & width: 22.91 cm	Average length: & width: cm
2.	Number and position of hair whorls on the body	***Whorl on the back (over the spine)***: i). Dhanaraasi sudi (Wealth hair whorl) is a single hair whorl located on top of the hump. It is considered the best. Breeding bulls with Dhanaraasi sudi are highly priced and are in demand. ii). Paataala sudi, is a single hair whorl located at the base of the hump towards the posterior side is considered second best to Dhanaraasi sudi. iii). Maamolu sudi (common hair whorl) is a single hair whorl located 4 inches away from the place of Paataala sudi towards the posterior side. iv). Dabbodu sudi, is a single hair whorl present close to the tail bone. v). Poraka sudi, is a single hair whorl present on the tail bone.	About 80% of the breeding bulls have Paataala sudi. About 20% of the breeding bulls have Dhanaraasi sudi. Breeding bulls with Paatala sudi are more common than bulls with Dhanaraasi sudi.	Position of hair whorls on the dewlap is not applicable to cows.

S.No.	*Codes Generated for Nallamala-Pasa/Kamma Cattle*	*Traditionally Deemed Desired Traits*	*Occurrence among Breeding Bulls (n = 95)*	*Occurrence among Cows (n = 197)*
		vi). Toda giri sudi, (hair whorl on thigh) is the single hair whorl present over tail at thigh region. ***On the Dewlap***: i). Potu sudi is the single hair whorl present on the left side of the dewlap. It is considered that a bull with Potu sudi is extremely virulent. ii). The bull with a hair whorl one on each side of the dewlap is considered good. iii). The bull with hair whorl only on the right side is considered unfit. ***On the forehead***: i). Manchi sudi, is the single hair whorl present right at the center of the forehead. It is considered good. ii). Kumpati sudi, is the hair whorl present towards the muzzle.		
3.	Nature of the hooves	Should be hard, thick, large, and firmly together, should not be split wide, and should not be loose		

S.No.	*Codes Generated for Nallamala-Pasa/Kamma Cattle*	*Traditionally Deemed Desired Traits*	*Occurrence among Breeding Bulls (n = 95)*	*Occurrence among Cows (n = 197)*
4.	Gait of the animal	Strides should be composed and firm. The stride should resemble a trot, lifting the feet off the ground and stepping firmly back, as if rocks would be crushed under the feet. There should not be any staggering or dragging of feet.		NA
5.	Shape of the legs	Should be thick and stout, and knees should not touch each other.		NA
6.	Colour of the horns	Slate	100%	100%
7.	Shape and orientation of the horns	Should be short, strong and wide at the base (especially for breeding bulls)	Average length: 15.35 cm	Average length: 19.38 cm
8.	Coat colour	White coat among cows and White coat with grey colour over the nape for breeding bulls	97%	89%
9.	Height of the animal	Less than 4.5 feet (137.16 cm) at the shoulder	Average Height: 135.82 cm	Average Height: 126.58 cm
10.	Temperament and response of the animal to instructions	Breeding bull should respond to the instructions of its care taker. It should play a major role in maintaining and protecting the herd. Breeding bulls are expected to lead the herd, warn / alert and protect the herd from		

S.No.	*Codes Generated for Nallamala-Pasa/Kamma Cattle*	*Traditionally Deemed Desired Traits*	*Occurrence among Breeding Bulls (n = 95)*	*Occurrence among Cows (n = 197)*
		predators and other dangers.		
11.	Duration of the observation	0 - 4 years	Male calves born during the 2 – 3 pregnancies are selected for breeding bulls. It is kept under constant observation since the time it was born till it is ready to mate when it is 4 years old.	NA

Both the study cattle breeds are maintained in herds and the average herd size of Poda Thurpu cattle is 45 (Siripurapu et al., 2019a) and the average herd size of Nallamala-Pasa/Kamma cattle is 75 (Siripurapu et al., 2019b). In both the cases a single breeding bull is maintained in the herd for breeding purpose. Traditionally local cattle breeders of both the cattle breeds follow an open nucleus breeding system for breeding (Bondoc and Smith, 1993; Shrivastava et al., 2018). Shrivastava et al. (2018), suggests that the average genetic merit of a nucleus herd is usually far greater and improves the overall genetic merit of the breed. Local cattle breeders are strictly against in-breeding among their cattle herds. They take precautions to discourage it among their herds. Inbreeding is considered morally wrong because local cattle breeders believe that it is equivalent to promotion of incest. Therefore, calves selected for breeding are usually sold or exchanged with other breeders and seldom are kept in the same herd which they were born into. This traditional practice prevents inbreeding and helps in maintaining healthy gene pool.

4. Conclusion

A combination of QuIK method, biometry data and qualitative methods for investigation was found to be effective in generating the desired data and results for the present study that examines ITK associated with the breeding of heritage breeds. Observations of the present study support the notion that traditional breeders of heritage breeds lay more emphasis on the qualitative traits than the quantitative traits. One of the highly valued qualitative traits by the local cattle breeders in a breeding bull is its temperament and its response to the instructions of the master. It was found that breeders of the study give significant importance to the fertility of bovine bulls than cows. Breeding bulls are meticulously chosen with extreme caution and care, following a very long and time-consuming selection process that could take up to four years. Traditionally local cattle breeders of both the cattle breeds follow an open nucleus breeding system for improving the overall genetic merit of the breed. Traditionally only men are involved in cattle breeding in the study area and women usually stay away from it. Inbreeding among the cattle is discouraged by the local cattle breeders by removing the male calves that were born into the herd. The local cattle breeders take a great interest in the number and position of hair whorls on the animals. However, further studies are necessary to develop a deeper understanding of the ITK associated with hair whorls, especially in the Indian context. Studies on hair whorls remain highly concentrated on hair whorls located on animal's head and information

about the same on other parts of the body is meagre. Furthermore, studies on hair whorls were predominantly conducted outside of India and there are hardly any studies found in the Indian context. Dearth of studies exploring such minute details and fine nuances, such as hair whorls in the Indian context leaves a huge gap in understanding the role of ITK in breeding and management of heritage breeds and indigenous livestock germplasm. The present study fills the existing information and knowledge gaps associated with ITK and breeding of heritage breeds in India. Besides, the study indicates the presence of priceless ITK and tacit knowledge associated with livestock breeding waiting to be discovered and scientifically documented. The study opens the doors for further studies on ITK associated with livestock breeding and management in India.

5. Acknowledgement

The authors would like to thank the traditional cattle breeders for appreciating our research, participating in the study, spending time and sharing their knowledge with us, without which this study would not have been possible. The authors would also like to thank profusely the Global Environment Facility (GEF), Telangana State Biodiversity Board and NBAGR-ICAR for supporting the biometry data collection and providing technical support. The authors would like to thank Megavardhan Reddy Pothula, Watershed Support Services and Activities Network (WASSAN) for the immense field support and data collection. WASSAN is also acknowledged for providing all the administrative support for the study. The authors would like to thank the anonymous reviewers for their valuable feedback which helped enormously in improving the article.

6. References

Aierqing, S., Nakagawa, A., Ouchi, Y., & Bungo, T. (2020). The effect of facial hair whorl position and raising environment on the temperament of the Chinese Yellow cattle in Shinjang Uyghur Aptonom Rayoni, China. *Journal of Advance Veterinary and Animal Research*, *7*(3), 477–481. https://doi.org/10.5455%2Fjavar.2020.g444.

Aksu, F., Baykara, B., Ergın, C., & Arman, C. (2013). Phenotypic features in autistic individuals: The finger length ratio (2D:4D), hair whorl, and hand dominance. *Turk Psikiyatri Derg. 24*, 94–100.

AP (Andhra Pradesh) Government (2019). *Kurnool District*. Retrieved from: https://kurnool.ap.gov.in/about- district/

Balaji. S. N., & Chakravarthy, P. C. (2010). Ethnoveterinary practices in India – A review. *Veterinary World*, *3*(12), 549-551.

Bawa, K. S., Sengupta, A., Chavan, V., Chellam, R., Ganesan, R., Krishnaswamy, J., Mathur, V. B., Nawn, N., Olsson, S. B., Pandit, N., Quader, S., Rajagopal, P., Ramakrishnan, U., Ravikanth, G., Sankaran, M., Shankar, D., Seidler, R., Shaanker, R. U., & Vanak, A. T. (2021). Securing biodiversity, securing our future: A national mission on biodiversity and human well-being for India. *Biological Conservation*, *253*. https://doi.org/10.1016/j.biocon.2020.108867.

Berkes, F., & Turner, N. J. (2006). Knowledge, Learning and the Evolution of Conservation Practice for Social-Ecological System Resilience. *Human Ecology*, *34*(4), 479-494.

Bhaduri, S., & Singh, A. (2012). Decline of traditional water harvesting systems during British India: Exploring the issues of knowledge incompatibility, breaking down of commons, and free ridership. Center for Studies in Science Policy, JNU, New Delhi.

Bondoc, O.L. & Smith, C. (1993). Deterministic genetic analysis of open nucleus breeding schemes for dairy cattle in developing countries. *Journal of Animal Breeding and Genetics.* 110(1-6):194-208. https://doi.org/10.1111/j.1439-0388.1993.tb00732.x.

Bora, S.K. (2022). Embryo sexing methods in bovine and its application in animal breed. *Journal of Animal Reproduction Biotechnology*, *37*: 80-86. https://doi.org/10.12750/JARB.37.2.80.

Borthakur, A., & Singh, P. (2012). Indigenous Technical Knowledge (ITK) and their Role in Sustainable Grassroots Innovations: An Illustration in Indian Context. In Proceedings of International Conference on Innovation & Research in Technology for Sustainable Development (ICIRT 2012), p. 38.

Broucek J., Uhrincat, M., Kisac, P., & Hanus A. (2004). Hair Whorl Position as a Predictor of Learning Ability and Locomotor Behaviour in Cattle? *Acta Vet Brno*, *73*, 455-459. Retrieved from: https://actavet.vfu.cz/media/pdf/avb_2004073040455.pdf.

Bruchac, M. (2014). Indigenous Knowledge and Traditional Knowledge. In Smith, C. (Ed.), *Encyclopedia of Global Archaeology*, 3814-3824. New York: Springer.

Butler, M.L., Bormann, J.M., Weaber, R.L., Grieger, D.M., and Rolf, M. (2020). Selection for bull fertility: a review. *Translational Animal Science, 4*(1): 423-441.

Casabianca, F., & Vallerand, F. (1994). Gerer les races locales d'animaux domestiques: une dialectique entre ressources genetiques et developpement regional. *Genetique Selection Evolution*, 26 Suppl. 1, 343-357.

CBD (Convention on Biological Diversity) (2021). Traditional Knowledge, Innovations and Practices: Article 8(J) Introduction. CBD Secretariat, a part of the United Nations Environment Programme (UNEP). Retrieved from: https://www.cbd.int/traditional/intro.shtml.

Census (2011). Amrabad Mandal – Mahbubnagar. *Population Census* (2011). Government of India. Retrieved from: https://www.census2011.co.in/data/subdistrict/4578-amrabad-mahbubnagar-andhra-%20pradesh.html"pradesh.html.

Clay, J. (2004). World agriculture and environment, Island Press, Washington DC, pp. 568.

Couse, A. (2015). Cowlicks: An Indicator of Attitude? Cornell Cooperative Extension of Jefferson County. Retrieved from: https://nydairyadmin.cce.cornell.edu/uploads/doc_540.pdf.

Craft, W. A., & Warner, E. A. (1934). Observation on different types of hair whorls in mammals and the inheritance of hair whorls in swine. *Academy of Science for 1933*. Oklahoma A. and M. College. Retrieved from: https://ojs.library.okstate.edu/osu/index.php/OAS/article/view/2808/2505.

Cresswell, J. W. (2013). *Qualitative Inquiry and Research Design, Choosing Among Five approaches*. CA: Sage.

Cruz, V. A. R., de A. Lima, D. F. P., Diaz, I. D. P. S., Curi, R. A., Costa, R. B., & de Camargo, G. M. F. (2021). Genetic parameters for hair whorl traits in horses. *Livestock Science*, *252*, 104679. https://doi.org/10.1016/j.livsci.2021.104679.

Csabi, G., Zsuppán, R., Jeges, S., & Tényi, T. (2014). Minor physical anomalies are more common in children with idiopathic epilepsy. *Neuropsychopharmacol Hung, 16*, 115–20.

DAFW (Department of Agriculture and Farmers Welfare) (2022). Rainfed Farming System. DAFW, Ministry of Agriculture and Farmers Welfare, New Delhi. Retrieved from: https://agricoop.gov.in/en/RainfedDiv.

DAHD (Department of Animal Husbandry and Dairying) (2023). Annual Report 2022 – 23. DAHD, Ministry of Fisheries, Animal Husbandry and Dairying, Govt. of India. Retrieved from: https://dahd.nic.in/sites/default/filess/FINALREPORT2023ENGLISH.pdf.

De Amitendu, H. P., Arya, S., Tudu, B., & Goswami, A. (2004). Indigenous Technical Knowledge in Animal Husbandry. *Livestock Research for Rural Development, 16*(8).

De Villiers, A.K. (1996). *Quantifying Indigenous Knowledge: A Rapid Method for Assessing Crop Performance without Field Trails*. Agricultural Research and Extension Network, Agren, Overseas Development Institute (ODI), London.

Deesing, M. (2020). Temperament traits and hair whorls. Folklore and Science. Deesing Livestock Systems. Retrieved from: https://deesinglivestocksystems.com/temperament-traits-and-hair-whorls/.

Devaki, K., & Mathialagan, P. (2015). Animal husbandry traditional knowledge in Kancheepuram district. *International Journal of Science, Environment and Technology*, *4*(5), 1289-1295. Retrieved from: https://www.ijset.net/journal/770.pdf.

Devendra, C. (2012). Agroforestry and silvopastoral systems potential to enhance food security and environmental sustainability in South East Asia. *Open Access Scientific Reports*. *1*(2). http://dx.doi.org/10.4172/scientificreports.163.

DTE (Down To Earth) (1997). Vanishing Breeds. *Down To Earth*, New Delhi. Retrieved from: http://www.indiaenvironmentportal.org.in/content/246/vanishing-breeds/.

Dubeux, J. C. B., Jr., Sollenberger, L. E., Gaston, L. A, Vendramini, J. M. B., Interrante, S. M., & Stewart, R. L. (2009). Animal Behavior and Soil Nutrient Redistribution in Continuously Stocked Pensacola Bahiagrass Pastures Managed at Different Intensities. *Crop Sci.*, *49*, 1503-10.

Dubeux, J. C. B., Jr., Sollenberger, L. E., Mathews, B. W., Schoberg, J. M., & Santos, H. Q. (2007). Nutrient Cycling in Warm-Climate Grasslands. *Crop Sci.*, *47*, 915-28.

Dwivedi, P. (2022). Development and conservation of indigenous cattle breed Kenkatha (Kenwariya). *Journal of Pharmacognosy and Phytochemistry*, *11*(6), 85-89.

Encina, A., Ligero, M., Sanchez-Guerrero, M. J., Los Terreros, A. R., Bartolome, E., & Valera, M. (2023). Phenotypic and genetic study of the presence of hair whorls in Pura Raza Espanol Horses. *Animals*, *13*(18), 2943. https://doi.org/10.3390/ani13182943.

FAO (The Food and Agriculture Organization of UN) (1999). Agricultural Biodiversity, Multifunctional Character of Agriculture and Land Conference, Background Paper 1. Maastricht, Netherlands. September, 1999.

FAO (The Food and Agriculture Organization of UN) (2023). Animal Production. FAO of the UN. Retrieved from: https://www.fao.org/animal-production/en/.

Fereday, J., & Muir-Cochrane, M. (2006). Demonstrating Rigor Using Thematic Analysis: A Hybrid Approach of Inductive and Deductive Coding and Theme Development. International *Journal of Qualitative Methods, 5*(1).

Francis, J. J., Johnston, M., Robertson, C., Glidewell, L., Entwistle, V., Eccles, M. P., & Grimshaw, J. M. (2010). What is an adequate sample size? Operationalising data saturation for theory-based interview studies, *Psychology & Health*, *25* (10), 1229-1245., https://doi.org/10.1080/08870440903194015.

Ghai, R. (2022). Over half of India's cattle, goat, sheep and swine are non-descript: Government. *Down To Earth*. Retrieved from: https://www.downtoearth.org.in/news/agriculture/over-half-of-india-s-cattle-goats-sheep-and-swine-are-non-descript-government-82826.

Grandin, T., Deesing, M. J., Struthers, J. J., & Swinker, A. M. (1995). Cattle with hair whorl patterns above the eyes are more behaviourally agitated during restraint. *Applied Animal Behaviour Science*, *46*(2), 117-123. https://doi.org/10.1016/0168-1591(95)00638-9.

Groeneveld, L. F., Lenstra J. A., Eding H., Toro, M. A., Scherf, B., Pilling, D., Negrini, R., Finlay, E. K., Jianlin, H., Groeneveld, E. J. A. G., & Weigend, S. (2010). Genetic diversity in farm animals—a review. *Animal Genetics. 41*(Suppl. 1), 6–31. https://doi.org/10.1111/j.1365-2052.2010.02038.x.

Haynes, R. J., & Williams, P. H. (1993). Nutrient Cycling and Soil Fertility in the Grazed Pasture Ecosystem. *Adv. Agron.*, *49*, 119-99.

Holtzman, J. S., (1986). *Rapid Reconnaissance Guidelines for Agricultural Marketing and Food System Research in Developing Countries, Food Security International Development.* Working Papers 54741, Michigan State University, Department of Agricultural, Food, and Resource Economics.

ICAR (Indian Council of Agricultural Research) (2004). Validation of Indigenous Technical Knowledge in Agriculture. ICAR, New Delhi. Retrieved from: https://shorturl.at/htDQ4.

ICAR-NBAGR (ICAR-National Bureau of Animal Genetic Resources) (2023). Registration of Farm Animal Germplasm. ICAR-NBAGR, Govt. of India. Retrieved from: https://nbagr.icar.gov.in/en/accession-numbers-of-registered-breeds-of-livestock-poultry/

ICAR-NBAGR (ICAR-National Bureau of Animal Genetic Resources) (2022). New breed registered. ICAR-NBAGR, Govt. of India. Retrieved from: https://nbagr.icar.gov.in/en/new-breeds-lines/.

ICAR-NBAGR (ICAR-National Bureau of Animal Genetic Resources) (2010). Breed Registration: ICAR-NATIONAL Bureau of Animal Genetic Resources, Karnal-132001 (Haryana), Breed Descriptor for Registration. Retrieved from: https://nbagr.icar.gov.in/wp-content/uploads/2019/12/cattle-buffalo-descriptor-format.pdf.

IFPRI and ILRI (2000). Property rights, risk, and livestock development in Africa. In: McCarthy N., Swallow B., Kirk M., and Hazell P. (eds), International Food Policy Research Institute (IFPRI) and International Livestock Research Institute (ILRI), Washington DC, pp 433.

IRIN (UN Integrated Regional Information Networks) (2007). Africa: Can pastoralism survive in the 21st century? World Press. Retrieved from: http://www.worldpress.org/Africa/2861.cfm/.

Jacob, C. T., Parida, A., & Kumar, K. K. (2020). Conservation of India's agrobiodiversity towards increasing food, nutritional and livelihood security. *Current Science*, *119*(4). Retrieved from: https://www.currentscience.ac.in/Volumes/119/04/0607.pdf.

Jaritz, G., Klenovec, C., & Schipflinger, F. (2010). *Rote Listen gefährdeter Tiere Österreichs: Alte Haustierrassen: Schweine, Rinder, Schafe, Ziegen, Pferde, Esel, Hunde, Geflügel, Fische, Bienen*. Wien: Böhlau Verlag.

Kiil, V. (1948). Frontal hair direction in mentally deficient individuals with special reference to mongolism. *Journal of Hered. 39*, 281–5.

Klar, A. J. S. (2003). Human handedness and scalp hair- whorl direction develop from a common genetic mechanism. *Genetics, 165*, 269-276.

Klar, A. J. S. (2005). A 1927 Study Supports a Current Genetic Model for Inheritance of Human Scalp Hair-Whorl Orientation and Hand-Use Preference Traits. *Genetics, 170*, 2027–2030. https://doi.org/10.1534/genetics.104.039990.

Kohler-Rollefson, I., & League for Pastoral Peoples (2003). Community-based management of animal genetic resources with special reference to pastoralists. Food and Agriculture Organization of the United Nations, Rome. Retrieved from: https://www.fao.org/3/y3970e/y3970e02a.htm#bm02.2.

Kothari, A. (1997). Conserving India's Agrobiodiversity: Prospects and policy implications. International Institute for Environment and Development (IIED), London. Retrieved from: https://www.iied.org/sites/default/files/pdfs/migrate/6119IIED.pdf.

Lanier, J. L., Grandin, T., Green, R., Avery, D., & McGee, K. (2001). A note on hair whorl position and cattle temperament in the auction ring. *Applied Animal Behaviour Science*, *73*(2), 93-101. https://doi.org/10.1016/S0168-1591(01)00132-0.

Leech, N. L., & Onwuegbuzie, A. J., (2007). An Array of Qualitative Data Analysis Tools: A Call for Data Analysis Triangulation. *School Psychology Quarterly*, *22*(4), 557–584.

Lillebo, S. (2014). Correlation between hair whorls and different types of behaviour in dogs (*Canis familiaris*). Norwegian University of Life Sciences. Retrieved from: https://shorturl.at/qbIz0.

Livestock Census (2019). The 20th Livestock Census of India-Key Results (Provisional). Ministry of Fisheries, Animal Husbandry and Dairying. Department of Animal Husbandry and Dairying, Krishi Bhavan, New Delhi. Retrieved from: https://epashuhaat.gov.in/documents/ProvisionalKeyResultsof20thLivestockCensus.pdf.

LPPS (Lokhit Pashu Palak Sansthan), & Köhler-Rollefson, I. (2005). *Indigenous Breeds, Local Communities, Documenting Animal Breeds and Breeding from a Community Perspective*. Lokhit Pashu Palak Sansthan (LPPS), India. ISBN: 81-901624-1-1. Retrieved from: http://www.lpps.org/wp-content/uploads/2013/07/ikab.pdf.

Luo, J., Huang, H., Qiao, H., Tan, J., Chen, W., Zhang, M., Ruiz-Linares, A., Wang, J., Yang, Y., Jin, L., Headon, D. J., & Wang, S. (2023). GWASs Identify Genetic Loci Associated with Human Scalp Hair Whorl Direction. *Journal of Investigative Dermatology*, *143*(10), 2065-2068. https://doi.org/10.1016/j.jid.2023.04.008.

Mahto, V.K. (2012). Study on indigenous technical knowledge (ITK) in animal husbandry among livestock owners of Jharkhand. BIRSA Agricultural University, Jharkhand, India. Retrieved from: https://shorturl.at/rSIZR.

Malathi, M., Chandrasekhar, L., & Thappa, D. M. (2013). Multiple hair whorls in a child with normal cranial and neurologic development. *Pediatr. Dermatol. 30*, 630–631.

Manomohan, V., Saravanan, R., Pichler, R., Murali, N., Sivakumar, K., Sudhakar, K., Naciappan, R. K., & Periasamy, K. (2021). Legacy of draught cattle breeds of South India: Insights into population structure, genetic admixture and maternal origin. *PLoS ONE, 16*(5), e0246497. https://doi.org/10.1371/journal.

Marsoner, T., Vigl, L. E., Manck, F., Jaritz, G., Tappeiner, U., 7 Tasser, E. (2018). Indigenous livestock breeds as indicators for cultural ecosystem services: A spatial analysis within the Alpine Space. *Ecological Indicators, 94*, 55-63. https://doi.org/10.1016/j.ecolind.2017.06.046.

Mashelkar, R. A. (2003). *The Golden Triangle*. Bio Spectrum. The Business of Bio and Health Sciences. Retrieved from: https://www.biospectrumindia.com/news/18/367/the-golden-triangle.html.

McDonald, J. H. (2011). Myths of Human Genetics. Sparky House Publishing, Baltimore, Maryland. Retrieved from: https://udel.edu/~mcdonald/mythhairwhorl.html.

Mir, I., Rautela, A., & Nimbalkar, V. (2020). Use of ethno veterinary medicine (EVM) in India for livestock management practices: A review. *International Journal of Current Microbiology and Applied Sciences*, *9*(6), 2319.

Mishra, A. K., Rama Rao, C. A., Subrahmanyam, K. V., Babu, M. V. S., Shivarudrappa, B., & Ramakrishna, Y. S. (2007). Strategies for livestock development in rainfed agro-ecosystem of India. *Livestock Research for Rural Development*, *19*(6). Retried from: https://lrrd.cipav.org.co/lrrd19/6/misr19083.htm.

MoEFCC (The Ministry of Environment, Forests and Climate Change) (2022). Annual Report 2021-22. Government of India. Retrieved from: https://moef.gov.in/wp-content/uploads/2022/03/Annual-report-2021-22-Final.pdf.

MoEFCC (The Ministry of Environment, Forests and Climate Change) (2018). Annual Report 2017-18. Government of India. Retrieved from: https://moef.gov.in/wp-content/uploads/2018/07/22-03-18.pdf.

MoFAHD (Ministry of Fisheries, Animal Husbandry and Dairying) (2022). 20th Livestock Census. MoFAHD, Government of India. Retrieved from: https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1813802.

Natarajan, A., Chander, M., & Bharathy, N. (2016). Relevance of Draught Cattle Power and its Future Prospects in India: A Review. *Agricultural Reviews*, *37*(1), 49-54.

Natarajan, S. N. S., Kumar, R., & Reddy, M.T. (2018). Chapter 8: Agrobiodiversity in India: Status and Concerns. In Biredra and Kumar, R.S. (eds.), *Sustainable Agriculture for Food Security: Concepts and Approaches*. Jodhpur, India: Scientific Publishers, p.121-138.

Nayar M. P., Singh A. K., & Nair, K.N. (2009). Agrobiodiversity Hotspots in India: Conservation and Benefit Sharing. PPV & FR Authority, NASC Complex, D.P.S. Marg, New Delhi, Vol. II, i-xii+ p.309. ISBN-978-81-908786-0-9.

Niranjan S. K., Kumar, A., Vineeth, M. R., Mohan, G., & Jayakumar, S. (2018). Status of dairy animal diversity in India. *Indian Dairyman*, *70*(9), 94-98.

Nivsarkar, A. E., Vij, P. K., & Tantia, M. S. (2013). Animal Genetic Resources of India – Cattle and Buffalo. Indian Council of Agricultural Research, New Delhi. ISBN: 978-81-7164-125-3. Retrieved from:

https://ia802808.us.archive.org/23/items/animalgeneticres0000nivs/animalgeneticres0000nivs.pdf.

NMSA (National Mission for Sustainable Agriculture) (2019). Rainfed Area Development. NMSA, Govt. of India. Retrieved from: https://nmsa.dac.gov.in/.

Nori, M., Switzer, J., & Crawford, A. (2005). Herding on the brink: towards a global survey of pastoral communities and conflict. An occasional paper. IUCN Commission on Environmental, Economic and Social Policy, Gland, Switzerland. Retrieved from: www.iisd.org/publications/pub.aspx?id=705/.

NSO (The National Statistical Office) (2022). First Revised Estimates of National Income, Consumption Expenditure, Saving and Capital Formation, 2020-21. Ministry of Statistics and Programme Implementation. Govt. of India. Retrieved from: https://shorturl.at/uXD1c.

Ogar, E., Pecl, G., & Mustonen, T. (2020). Science Must Embrace Traditional and Indigenous Knowledge to Solve Our Biodiversity Crisis. One Earth, Vol. 3(2), pp. 162-165. https://doi.org/10.1016/j.oneear.2020.07.006.

Outlook (2021). Kerala's Periyar Cow gets new lease of life in the face of extinction. *Outlook*, 08 July 2021. Retrieved from: https://www.outlookindia.com/website/story/india-news-new-lease-of-life-for-periyar-cow-facing-extinction-threat/387463.

Padmakumar, V. (1998). Farmers' reliance on Ethnoveterinary practices to cope with common cattle ailments. *Indigenous Knowledge and Development Monitor, 6*(2), 20.

Phaniraja, K. L., & Panchasara, H. H. (2009). Indian draught animal power. *Veterinary World*, *2*(10), 404-407.

Prajuli, D. R., & Das, T. (2013). Indigenous Knowledge and Biodiversity Interconnectedness for Sustainable Development. *International Journal of Scientific & Technology Research*, *2*(8). Retrieved from: http://www.ijstr.org/final-print/aug2013/Indigenous-Knowledge-And-Biodiversity-Interconnectedness-For-Sustainable-Development..pdf.

Prakash, N., Roy, S.S., & Ngachan, V. (n.d.). Role of ITK in conservation agriculture: Blending Indigenous and scientific knowledge. ICAR Research complex for NEH region, Meghalaya. Retrieved from: https://kiran.nic.in/pdf/publications/ITK.pdf.

Quelhas, J., Santiago, J., Matos, B., Rocha, A., Lopes, G., & Fardilha, M. (2021). Bovine semen sexing: Sperm membrane proteomics as candidates for immunological selection of X- and Y-chromosome-bearing sperm. *Veterinary Medicine and Science*, *7*(5): 163-1641. https://doi.org/10.1002/vms3.540.

Rajan, S. & Sethuraman, M. (1997). Traditional veterinary practices in rural areas of Dindigul district, Tamilnadu, India. *Indigenous Knowledge and Development Monitor, 5*(3), 15.

Rangnekar, D.V. (1998). Random thoughts on Ethno veterinary Practices and their Validation in relation to Livestock Development in India. ICAR short course entitled "*Techniques for scientific validation and Evaluation of Ethno veterinary practices*" pp. 24-27.

Ravikumar, R.K., Thakur, D., Choudhary, H., Kumar, V. , Kinhekar, A. S., Garg, T., Ponnusamy, K., Bhojne, G. R., Shetty, V. M., & Kumar, V.(2017). Social engineering of societal knowledge in livestock science: Can we be more empathetic? *Veterinary World*, *10*(1), 86-91.

Ruiz-Maldonado, R. (2002). A previously unreported syndrome of multiple scalp whorls and associated anomalies. *Clin Exp Dermatol., 27*, 21–3.

Sechi, A., Neri, I., Patrizi, A., Starace, M., Savoia, F., Leuzzi, M., Dante Caposiena Caro, R., & Piraccini, B. M. (2020). Scalp hair whorl patterns in patients affected by Neurofibromatosis Type 1: A case control study. *International Journal of Trichology*, *12*(2), 56-61. https://doi.org/10.4103%2Fijt.ijt_25_20.

Shagun (2023). India now has 212 indigenous livestock breeds after ICAR-NBAGR registers 10 new ones. *Down To Earth*. Retrieved from: https://www.downtoearth.org.in/news/agriculture/india-now-has-212-indigenous-livestock-breeds-after-icar-nbagr-registers-10-new-ones-86957.

Sharma, V. P., Kohler-Rollerfson I., 7 Morton, J. (2003). Pastoralism in India. A Scoping Study. DFID, New Delhi. Retrieved from: https://assets.publishing.service.gov.uk/media/57a08ce2e5274a31e00014fa/ZC0181b.pdf.

Shrivastava, A. K., Khandelwal, N. K., Dubey, R. K., & Guru, P. K. (2021). Long term study of declining animal usage in Indian agriculture. *Agricultural Engineering International, 23*(1), 109-114.

Shrivastava, K., Sinha, R., Pathak, P., & Nayak, V.K. (2018). Open nucleus breeding system to improve livestock population: a review. *International Journal of Pure and Applied Bioscience. 6*(5): 892-899. http://dx.doi.org/10.18782/2320-7051.6579.

Shubeena, S., Hai, A., Hamdani, S.A. & Akand, A.H. (2018). Indigenous Technical Knowledge (ITKs) Used by Farmers of Central Kashmir to Increase Production and Reproduction in Livestock. *International Journal of Livestock Research, 8*(8), 294-302.

Silveira, M. L., Joao, M. B., Vendramini, M. B., da Silva, H. M., & Azenha, M. (2013). Nutrient Cycling in Grazed Pastures. SL376/SS578, 1/2013". *EDIS, 2013*(2). https://doi.org/10.32473/edis-ss578-2013.

Simon, P. B., Joseph, J. O., Ochieng, J. W., Tiambo, C. K., Tarekegn, G. M., Machuka, E. M., Kabange, D., Kusale, K., Ciza, A. M., Kizungu, R. V., & Pelle, R. (2021). Typology, management and smallholder farmer-preferred traits for selection of indigenous goats (*Capra hisrcus*) in three agro-ecological zones in the Democratic Republic of Congo. *Journal of Applied Animal Research*, *49*(1), 423-430. https://doi.org/10.1080/09712119.2021.1995393.

Singh, S. P., & Singh, S. (2021). Farm power availability and its perspective in Indian agriculture. *RASSA Journal of Science for Society*, *3*(2), 114-126.

Siripurapu, K. K. (2022). Policy Brief: Extension of the National Programme for Bovine Breeding and Dairy Development for Draught Purpose Bovine Breeds of India. SaciWATERs, India. Retrieved from: https://shorturl.at/fWaYc.

Siripurapu, K. K. (2023). The traditional sheep penning system: An exploratory study on farmers' preferences, farmer-pastoralist relationships, and economics of sheep penning in Telangana, India. *Pastures & Pastoralism, 01*, 52-73. https://doi.org/10.33002/pp0105.

Siripurapu, K. K., & Iyengar, S. (2023). Biocultural diversity and culture animals in mobile pastoralism: Cattle-culture of pastoralists of Telangana state, India. *Pastures & Pastoralism*, *01*, 25-37. https://doi.org/10.33002/pp0103.

Siripurapu, K. K., Das, S., Pundir, R. K., Tantia, M. S., Akinepalli, V. R., & Reddy, M. (2019b). Characterization of the Indigenous Nallamala-Kamma Cattle Population of Andhra Pradesh, India. http://dx.doi.org/10.13140/RG.2.2.32608.02564.

Siripurapu, K. K., Das, S., Sharma, S., Akinepalli, V. R., Reddy, M., & Yadav, V. (2019a). Characterization of PodaThurpu Cattle: A Native Livestock Population of Telangana State. *Journal of Livestock Biodiversity*, *9*(1).

Siripurapu, K. K., Iyengar, S. Saberwal, V., & Das, S. (2020). An Overview of Mobile Pastoralism in Andhra Pradesh and Telangana States of the Deccan Plateau Region of India. Center for Pastoralism, WASSAN and RRAN, India. Retrieved from: https://shorturl.at/Fccaz.

Siripurapu, K. K., Kulkarni, S., & Das, S. (2021). Understanding the Indigenous socio-cultural, economic and ecological systems of Indigenous livestock breeds for designing appropriate extension services and delivery systems. *Journal of Livestock Biodiversity*, *10*.

Slade, J., & Yoong, P. (2014). The Types of Indigenous Knowledge to be retained for Young New Zealand Based Samoans: A Samoan Grandparents' Perspective. Pacific Asia Conference on Information Systems (PACIS), 2014 Proceedings, 161. Retried from: http://aisel.aisnet.org/pacis2014/161.

Smith, D. W., & Gong, B.T. (1974). Scalp-hair patterning: Its origin and significance relative to early brain and upper facial development. *Teratology, 9*, 17–34.

Smith, D. W., 7 Gong, B. T. (1973). Scalp hair patterning as a clue to early foetal brain development. Paediatrics, 83, 374-380. https://doi.org/10.1016/S0022-3476(73)80258-6.

Sollenberger, L. E., Dubeux, Jr, J. C. B., Santos, H. Q., & Mathews, B. W. (2002). "Nutrient Cycling in Tropical Pasture Ecosystems." In Batista et al. 9eds.), *Reuniao Annual da Soc Bras Zootecnia SBZ*, p.151-79. PE: Recife.

Soni, M. L., Subbulakshmi, V., Yadava, N. D., Tewari, J. C., & Dagar, J. C. (2016). Silvopastoral Agroforestry Systems: Lifeline for Dry Regions. In: Dagar, J. C. and Tewan, J. C., (eds.), *Agroforestry Research and Developments*, Chapter 9. Nova Science Publishers. ISBN: 978-1-63485-046-9.

Sow, S., & Ranjan, S. (2021). Indigenous Technical Knowledge (ITK) for Sustainable Agriculture in India. *Agriculture & Food*.Retrieved from: https://www.researchgate.net/publication/349278516_Indigenous_Technical_Knowledge_ITK_for_Sustainable_Agriculture_in_India.

Srivastava, A. K., Patel, J. B., Ankuya, K. J., Chauhan, H. D., Pawar, M. M., & Gupta, J. P. (2019). Conservation of Indigenous Cattle Breeds. *Journal of Animal Research*, *9*(1), 01-12. https://doi.org/10.30954/2277-940X.01.2019.1.

Strauss, A. L. (1987). Qualitative Analysis for Social Scientists. Cambridge: Cambridge University Press. https://doi.org/10.1017/CBO9780511557842.

Swiderska, K. (2020). Protecting indigenous cultures is crucial for saving the world's biodiversity. International Institute for Environment and Development, London. Retrieved from: https://www.iied.org/protecting-indigenous-cultures-crucial-for-saving-worlds-biodiversity.

Tada, O., Muchenje, V., & Dzama, K. (2013). Preferential traits for breeding Nguni cattle in low-input in-situ conservation production systems. *SpringerPlus*, *2*, 195.

Telangana Gov ernment (2019). Nagarkurnool. Retrieved from: http://nagarkurnool.telangana.gov.in/.

Tirosh, E., Jaffe, M., & Dar, H. (1987). The clinical significance of multiple hair whorls and their association with unusual dermatoglyphics and dysmorphic features in mentally retarded Israeli children. *Eur. J. Pediatr.,* 146, 568–70.

Tomkins, L. M., & McGreevy, P. D. (2010). Hair whorls in the dog (*Canis familiaris*), Part II: Asymmetries. *The Anatomical Record*, *293*, 513–518. https://doi.org/10.1002/ar.21077.

UNCCD (United Nations Convention to Combat Desertification) (2017). Drylands. In: Global Land Outlook – First Edition. UNCCD, Germany. Pp 246-269. ISBN: 978-92-95110-48-9. Retrieved from: https://catalogue.unccd.int/823_GLO_Full_Report_ENG.pdf.

Venkateswarlu, B., Singh, A.K., Prasad, G., Chary, R., Rao, S.C., Rao, K.V., Ramana, D.B.V., and Rao, V.U.M. (2011). District level contingency plans for weather aberrations in India. Central Research Institute for Dryland Agriculture, Natural Resources Management Division, ICAR, India, p.136. Retrieved from: https://icar-crida.res.in/crida%20old%20website/CRIDA%20new/assets/img/Books/2011-12/contingency%20plans%20book.pdf.

Authors' Declarations and Essential Ethical Compliances

Authors' Contributions (in accordance with ICMJE criteria for authorship)

Contribution	*Author 1*	*Author 2*	*Author 3*	*Author 4*	*Author 5*
Conceived and designed the research or analysis	Yes	Yes	Yes	No	No
Collected the data	Yes	No	No	Yes	No
Contributed to data analysis & interpretation	Yes	Yes	No	No	No
Wrote the article/paper	Yes	No	No	No	No
Critical revision of the article/paper	Yes	Yes	Yes	Yes	Yes
Editing of the article/paper	Yes	Yes	Yes	Yes	Yes
Supervision	No	Yes	Yes	No	Yes
Project Administration	No	No	Yes	Yes	No
Funding Acquisition	No	No	Yes	No	No
Overall Contribution Proportion (%)	40	20	30	5	5

Funding
The funding for this research was made available by the Global Environment Facility (GEF), Telangana State Biodiversity Board and National Bureau of Animal Genetic Resources-ICAR, India, for collection of biometry data. Although the main objetive of the funding was not about studying the traditional cattle breeding practices but the richness of data and information guided us in the new direction and contributed to designing and conducting this study.

Research involving human bodies or organs or tissues (Helsinki Declaration)
The author(s) solemnly declare(s) that this research has not involved any human subject (body or organs) for experimentation. It was not a clinical research. The contexts of human population/participation were only indirectly covered through literature review. Therefore, an Ethical Clearance (from a Committee or Authority) or ethical obligation of Helsinki Declaration does not apply in cases of this study or written work.

Research involving animals (ARRIVE Checklist)
The author(s) solemnly declare(s) that this research has not involved any animal subject (body or organs) for experimentation. The research was not based on laboratory experiment involving any kind of animal. Some contexts of animals are also indirectly covered through literature review. Therefore, an Ethical Clearance (from a Committee or Authority) does not apply in cases of this study or written work.

Research on Indigenous Peoples and/or Traditional Knowledge
The author(s) solemnly declare(s) that this research has involved Indigenous Peoples as participants or respondents, with the documentation of their Indigenous Knowledge. Some other contexts of Indigenous Peoples or Indigenous Knowledge are only indirectly covered through literature review. An Ethical Clearance 'to conduct research on indigenous peoples' Indigenous knowledge is relevant. Therefore, an Ethical Clearance (from a Committee or Authority) and Self-Declaration in this regard do apply in cases of this study or written work. Both the documents are appended.

Research involving Plants
The author(s) solemnly declare(s) that this research has not involved the plants for experiment or field studies. The contexts of plants were only indirectly covered through literature review. Thus, during this research the author(s) obeyed the principles of the Convention on Biological Diversity and the Convention on the Trade in Endangered Species of Wild Fauna and Flora.

(Optional) Research Involving Local Community Participants (Non-Indigenous)
The author(s) solemnly declare(s) that this research has not involved local community participants or respondents belonging to non-Indigenous peoples. Yet, this study did not involve any child in any form directly. The contexts of different humans, people, populations, men/women/children and ethnic people are also indirectly covered through literature review. Therefore, an Ethical Clearance (from a Committee or Authority) or prior informed consent (PIC) of the respondents or Self-Declaration in this regard does not apply in cases of this study or written work.

(Optional) PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses)
The author(s) has/have NOT complied with PRISMA standards. It is not relevant in case of this study or written work.

Competing Interests/Conflict of Interest
Author(s) has/have no competing financial, professional, or personal interests from other parties or in publishing this manuscript. There is no conflict of interest with the publisher or the editorial team or the reviewers.

Attribution and Representation
All opinions and mistakes are the author(s)' own and cannot be attributed to the institutions they represent. The publisher is also not responsible either for such opinions and mistakes in the text or graphs or images.

Rights and Permissions

Open Access. This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license, and indicate if changes were made. The images or other third-party material in this article are included in the article's Creative Commons license, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons license and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this license, visit http://creativecommons.org/licenses/by/4.0/.

***

To see original copy of these declarations signed by Corresponding/First Author (on behalf of other co-authors too), please download associated zip folder [Ethical Declarations] from the published Abstract page accessible through and linked with the DOI: https://doi.org/10.33002/pp0204.

WASSAN

PRIOR INFORMED CONSENT (PIC) LETTER

Dt: 16/05/2019

From
Kanna K. Siripurapu
Sr. Project Officer, WASSAN.

To
The Chair Person,
Amrabad Poda Lakshmi Govu Sangham,
H.No. #15-148, Sainagar Colony,
Atchampeta – 509375, Nagarkurnool district,
Telangana, India.

Sub: PIC of Biocultural Diversity of Pastoralists documented from members of Amrabad Poda Lakshmi Govu Sangham (APLGS), for nomination of APLGS regarding. (1). to nominate APLGS for the India Biodiversity Conservation Award, 2021. And (2). to publish the study in journals, giving due credit to APLGS and pastoralists rearing the Indigenous Poda Thurpu cattle breed.

Dear Sir,

With reference to the above cited subject, I would like to bring to your kind notice that the Watershed Support Services and Activities Network (WASSAN), a NGO based out of Hyderabad, India, is planning to conduct a participatory research study on Biocultural Diversity of Pastoralists of Telangana, India.

It was believed and widely accepted that the knowledge and information related to Biocultural Diversity of Pastoralists in connection with the Indigenous Poda Thurpu cattle breed is a common knowledge, which is shared among the Pastoralist communities of your region. And, APLGS is the representative body of the pastoralists keeping the Indigenous Poda Thurpu cattle breed and Biocultural Diversity of the same.

In this connection, I would like to approach you for your consent and permission to participatory documentation of Biocultural Diversity of Pastoralists involved in rearing and breeding the Indigenous Poda Thurpu cattle breed in Telangana state.

I would like to seek your approval for the same. The information thus documented will be primarily used for (1). Nomination of APLGS for the India Biodiversity Conservation Award, 2021. And (2). Publication of the study in journals, giving due credit to APLGS and pastoralists.

If you are approval of our proposal, we would like to request you to kindly sign this letter below and provide a copy of the same as a proof of your consent and approval of the same.

Thanking you!
(Kanna K. Siripurapu)

With reference to the above cited subject, being the Chair Person of APLGS, I hereby approve the same.

(Chair Person, APLGS)

Amrabad Poda Lakshmi Govu Sangham

Watershed Support Services and [illegible] Network
Plot # 665, Street No.12, Lakshmi Narasimha Colony, [illegible] Road – 500 068
Ph: 040 - 27015295 / 96, 27016581, E-mail: [illegible] Website: www.wassan.org

SELF-DECLARATION FORM
Research on Indigenous Peoples and/or Traditional Knowledge

The nature and extent of community engagement should be determined jointly by the researcher and the relevant community or collective, taking into account the characteristics and protocols of the community and the nature of the research.

If your research involved/involves the Indigenous Peoples as participants or respondents, you should fill in and upload this Self-Declaration and/or Prior Informed Consent (PIC) from the Indigenous Peoples. [Please read carefully https://grassrootsjournals.org/credibility-compliance.php#Research-Ethics]

1. Conditions of the Research

1.1 Was or will the research (be) conducted on (an) Indigenous land, including reserve, settlement, and land governed under a self-government rule/agreement or?

No

1.2 Did/does any of the criteria for participation include membership in an Indigenous community, group of communities, or organization, including urban Indigenous populations?

No

1.3 Did/does the research seek inputs from participants (members of the Indigenous community) regarding a community's cultural heritage, artifacts, traditional knowledge, biocultural or biological resources or unique characteristics/practices?

Yes, the research seeks information on the traditional technical knowledge related to cattle breeding.

1.4 Did/will Aboriginal identity or membership in an Indigenous community used or be used as a variable for the purposes of analysis?

No

2. Community Engagement

2.1 If you answered "Yes" to questions 1.1, 1.2, 1.3 or 1.4, have you initiated or do you intend to initiate an engagement process with the Indigenous collective, community or communities for this study?

Yes, one of the participant pastoralist communities in the study belongs to Lambadi/Sugali community (also known as Banjara/Vanachara), notified as a Nomadic Tribes as per the Ministry of Tribal Affairs, Government of India. However, Lambadi/Sugali

are not necessarily recognized as the Scheduled Tribes among a few states of the Indian sub-continent. But, Lambadi/Sugali are classified as the Scheduled Tribes in Andhra Pradesh and Telangana state, which is also the study area.

Since 2018, I have been closely associated with the Amrabad Poda Lakshmi Govu Sangham (APLGS) and Nallamala-Kamma Govu Sangham (NKGS), the collectives of Poda Thurpu and Nallamala-Pasa/Kamma cattle breeders, of Nagarkurnool and Kurnool districts of Telangana and Andhra Pradesh states. I have been working with the associations for conservation of the indigenous Poda Thurpu and Nallamala-Pasa/Kamma cattle breeds and improvement of local livelihoods.

In the year 2019, a formal process was initiated with APLGS and NKGS for participatory research and documentation of biocultural diversity of pastoralists associated with breeding of the cattle breeds. The main objectives of such documentation was: (1). To nominate APLGS for the India Biodiversity Conservation Award, 2021. The documentation helped APLGS, in winning the India Biodiversity Conservation Award, 2021. For more information about the award: https://www.ecosystemsbasedsolutions.in/telangana-3.php (2). To publish the study in journals, giving due credit to APLGS and pastoralists. And (3). To register Nallamala-Pasa/Kamma as defined native cattle breed with the ICAR-NBAGR, India.

2.2 If you answered "Yes" to question 2.1, describe the process that you have followed or will follow with respect to community engagement. Include any documentation of consultations (*i.e., formal research agreement, letter of approval, PIC, email communications, etc*.) and the role or position of those consulted, including their names if appropriate:

A formal letter of prior informed consent (PIC) was shared with the Executive Committee members and Chair Person of APLGS and NKGS, expressing the intentions (mentioned in response to Q. #2.1.), behind the participatory research study and sought their approval for the same. Upon, the receipt of formal letter of approval from the Chair Person of APLGS, participatory documentation of biocultural diversity of pastoralists was initiated for the objectives #1 and #2 mentioned in response to Q. #2.1. A copy of the same will be annexed with this form.

3. No Community Consultation or Engagement

If you answered "No" to question 2.1, briefly describe why community engagement will not be sought and how you can conduct a study that respects Aboriginal/ Indigenous communities and participants in the absence of community engagement.

Name of Principal Researcher: Kanna Kumar Siripurapu
Affiliation of Principal Researcher: School of Arts and Design, Woxsen University, Kamkole, Sadasivpet, Sangareddy District, Hyderabad - 502 345, Telangana, India. Website: https://woxsen.edu.in/

Declaration: Submitting this note by email to any journal published by The Grassroots Institute is your confirmation that the information declared above is correct and devoid of any manipulation.