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Seasonal variation on phytosociology and carrying capacity of sheep in different pasture systems

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ABSTRACT

The field experiments were conducted at the Livestock Farm Complex, Tamil Nadu Veterinary and Animal Sciences University, Chennai, Tamil Nadu, India. Five years old Silvipasture and hortipasturesystems established in an acre at livestock farm complex were taken for the study. The species under the storey of the trees were identified, and counted for calculation of phytosociology indices and palatability. Based on the biomass collected seasonally were used for calculation of carrying capacity and water use efficiency of pastures. The results showed that 20 and 6 species were identified under the storey of the trees in the pasture systems. The phytosociological indices revealed that the major species belonged to graminacea family followed by cyperaceae and amaranthaceae in silvipasture system and graminaceae and fabaceae in hortipasture system. Irrespective of the pasture system, higher biomass was produced during kharif season followed by rabi season. The higher biomass production of 1959.5± 41.4 kg ha^{-1} was recorded with hortipasture system followed by 1876.2± 39.7 kg ha^{-1} during rabi season under hortipasture system. Under silvipasture system, during rabi season, the biomass produced was 1318.2± 15.2 kg ha^{-1} and during kharif season, the biomass production was 1122.4± 13.0 kg ha^{-1}. The carrying capacity of 10.74 sheep ha^{-1} was calculated for kharif season under hortipasture system and 7.3 sheep ha^{-1} for silvipasture system. The lowest carrying capacity was during the winter season (5.40±0.0012 sheep ha^{-1} and 4.1± 0.0063 sheep ha^{-1}) during hortipasture and silvipasture system respectively. Water use efficiency obtained during summer season was highest during the summer season (2.06 kg mm^{-1}) under the hortipasture system, whereas silvipasture system recorded 1.525 2.06 kg mm^{-1}. The lowest water use efficiency of 0.171 kg mm^{-1} was recorded under hortipasture system and 0.103 kg mm^{-1} was recorded under silvipasture system during rabi season.

Keywords: *Pasture, Phytosociological indices, Seasonal variation, Carrying capacity, Water use efficiency*

Introduction

In India, grazing based livestock husbandry continues to play an important role in rural economy of the country as around 50 per cent animals depend on grazing in forests and other grazing areas. In Tamil Nadu, grasslands/ rangelands are a major source of feed and fodder for the livestock. Sheep rearing is an important economic activity mainly by landless agricultural laborers and small and marginal farmers. Sheep rearing is a sustainable livelihood option for poor farmers to face the adverse conditions due to drought situation since they are maintained under grazing. It provides gainful self-employment, improved nutrition and additional income to poor farmers. Mostly, the land area under grasslands or rangelands are declining as these were used for various other activities leading to urbanization (Calicioglu *et al*., 2019). Though there is a transformation in rearing of sheep from extensive or semi intensive system of rearing to intensive system of rearing, still 30-40% of the sheep are reared under extensive or semi intensive system. Hence, there occurs a need for establishment and maintenance of grasslands or rangelands. As the land area is limited, the wastelands can be very well utilized. Here come the agroforestry systems.

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In the agroforestry systems, Silvipasture and hortipasture systems are viable technologies to rehabilitate degraded wastelands and provide fodder and serves as a sustainable land use technology for livestock production (Nair and Nair, 2014). Ample studies reveal that different pastures of agroforestry models can be utilized for pasturing by animals. Hence, the study was conducted to understand the phytosociology of species, biomass production, carrying capacity and water use efficiency of species under silvipasture and hortipasture systems.

Materials and Methods

The study was conducted at Livestock Farm Complex, TANUVAS, Chennai in the established pastures (Silvi pasture and Hortipasture). Silvipasture comprised of gliricidia as tree component along with natural vegetation. Hortipasture comprised of mangoes as tree component and the understorey comprised of guinea grass. The established pastures in one acre were five years old. Vegetation under the storey were collected using transect method in around 24 sample units. The palatable species were observed. The incremental growth of the plants above the ground in the sampled area were calculated for the above ground biomass. The sequential growth once in 20 days for the above ground biomass were calculated for the seasons such as kharif, rabi, winter and summer. Phytosociology of species were calculated i.e for relative density of species, relative frequency and area of species under silvipasture and hortipasture system (Sachin Kumar *et al*., 2023). The carrying capacity was calculated based on the number of livestock per hectare (Brown, 1954).

Carrying capacity is calculated based on the total forage production, proper forage use factor and animal requirement. Proper forage use factor was taken as 60% of the above ground biomass production. Based on the requirement of the animals, animal requirement was calculated. The dry matter of the sheep was calculated using 0.25 animal unit equivalent (Miranda Meehan *et al*., 2018). Water use efficiency in the pasture was calculated using net above ground primary production and the quantity of rainfall obtained during the season.

Results and discussion

Phytosociology of plant species in different pasture systems:

About 20 and 6 pasture species were found in silvi pasture and hortipasture systems respectively (Table 1 and 2). The major species belongs to graminaceae family, followed by cyperaceae and amaranthaceae in silvi pasture system, and graminaceae followed by fabaceae in hortipasture system. The dominant species of silvipasture system are Digitaria ciliaris and Setaria viridis, both found to be palatable for livestock. Legume species were found negligible in silvipasture system. In comparision with relative component of palatable species, more palatable species were present in silvipasture than hortipasture system. This also reflected on the diversity of species which was found higher in silvipasture system than hortipasture system. The palatable weed species exhibited a pattern of variation in the total count of the weeds, as these are influenced by seasonal variation. This is in accordance with the findingsof Concenço et al. (2017).

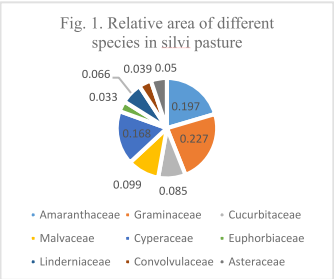
Frequency is used to avoid under estimation of abundance of individual species (Travlos, 2013). Relative frequency of species of graminaceae family was higher in silvipasture system followed by cyperaceae and amaranthaceae. Similarly, in hortipasture system, the relative frequency of species of graminaceae was higher followed by fabaceae. In general, the species richness was higher with silvipasture system and lesser in hortipasture system. Relative area of the species (Table1 and 2, Fig. 1 and 2) also shows similar pattern. Graminaceae species were found dominant in both silvipasture and hortipasture system, showing its highest adaptability to the environment, tolerance to grazing. The grasses were found dominant due to its ability to tolerate grazing and their quicker ratooning compared to other species (Kohli *et al*., 2004).

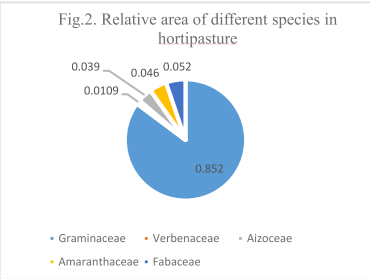
Table 1. Phytosociology of species in silvipasture system

Species	Family	Relative density (%)	Relative frequency (%)	Relative area	Palatability
Achyranthes aspera	Amaranthaceae	4.17	5.41	0.012	P
Sida cordifolia	Malvaceae	0.43	1.35	0.022	NP
Cyperus iria	Cyperaceae	3.07	4.05	0.044	P
Amaranthus spinosus	Amaranthaceae	7.03	6.75	0.058	P
Phyllanthus niruri	Phyllanthaceae	1.75	6.75	0.036	P
Setaria viridis	Graminaceae	6.92	6.08	0.009	P
Acmella oppositifolia var.repens	Asteraceae	4.39	3.37	0.05	NP
Convolvulus arvensis	Convolvulaceae	2.96	4.73	0.039	NP
Melothria pendula	Cucurbitaceae	0.98	2.02	0.036	P
Cucumis melo var.agrestis	Cucurbitaceae	2.85	4.05	0.049	P
Torenia crustacea	Linderniaceae	9.67	6.76	0.066	P
Panicum maximum	Graminaceae	4.39	6.75	0.089	P
Digitaria ciliaris	Graminaceae	11.86	6.75	0.073	P
Echinocloa colono	Graminaceae	1.09	2.70	0.056	P
Fimbristylis miliaceae	Cyperaceae	9.01	3.37	0.058	MP
Cyperus rotundus	Cyperaceae	9.78	6.08	0.066	P
Corchorus species	Malvaceae	2.85	6.76	0.077	P
Ricinus communis	Euphorbiaceae	0.65	2.70	0.033	NP
Alternethera sessilis	Amaranthaceae	9.01	6.75	0.068	P

Table 2. The phytosociology of species in hortipasture system

Species	Family	Relative density (%)	Relative frequency (%)	Relative area	Palatability
Digitaria ciliaris	Graminaceae	13.79	20.51	0.056	P
Panicum maximum	Graminaceae	55.17	25.64	0.796	P
Phyla nodiflora	Verbenaceae	8.27	5.128	0.0109	NP
Trianthema portulacastrum	Aizoceae	4.14	12.82	0.039	P
Alternenthera echinata	Amaranthaceae	8.28	15.38	0.046	NP
Stylosanthus sp.	Fabaceae	10.34	20.51	0.052	P





Biomass production under different pasture systems:

The above ground biomass potential of different pasture system carried out at different seasons are presented in table (3). Irrespective of the pasture system, higher biomass was produced during kharif season followed by rabi season. However, the higher biomass was recorded under hortipasture system in comparision to silvipasture system. The higher biomass production of 1959.5± 41.4 kg ha^{-1} was recorded with hortipasture system followed by 1876.2± 39.7 kg ha^{-1} during rabi season under hortipasture system.

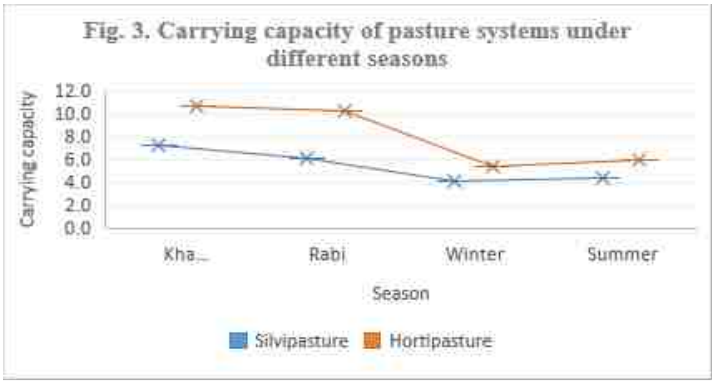
Under silvipasture system, during rabi season, the biomass produced was 1318.2± 15.2 kg ha^{-1} and during Kharif season, the biomass production was 1122.4± 13.0 kg ha^{-1}. The biomass produced under hortipasture system was about 32.68% higher than the silvipasture system during the period of study. The above ground biomass productivity was significantly influenced by precipitation, which is supported by the findings of Hossain and Beierkuhnlein, (2018). However, the increase in temperature indirectly reduced biomass production by improving soil nutrient status during summer season. Hence the biomass was comparatively higher than winter (Kahmen *et al*., –2005, Chen et al. –2017). After monsoon, the higher temperature can lower above ground biomass productivity by reducing water availability that increases evapotranspiration and limits photosynthesis (De Boeck et al. –2011). Hence, during winter season, as there is an increase in temperature and limited precipitation the biomass was found less in silvipasture and hortipasture system. This is in line with the findings of Jentsch et al. (2014).

Table 3. above ground biomass production under different pasture systems

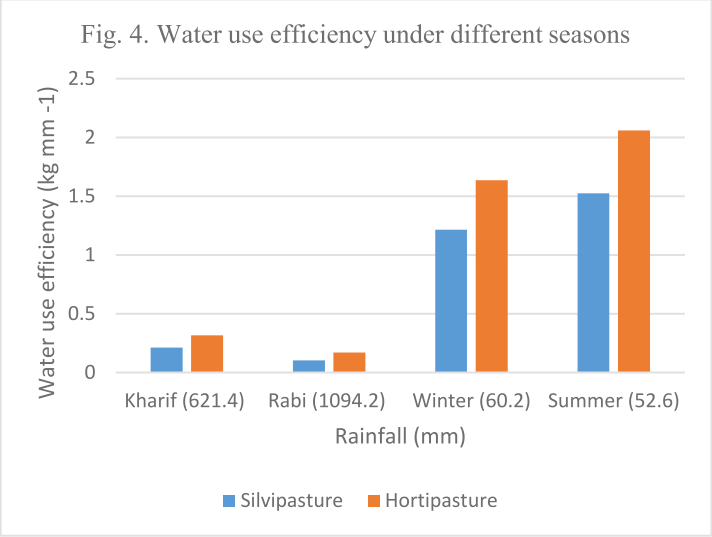
Season/ Pasture	Above ground biomass (kg ha^{-1})	
	Silvipasture	Hortipasture
Kharif	1318.2 ± 15.2	1959.5 ± 41.4
Rabi	1122.4 ± 13.0	1876.2 ± 39.7
Winter	731.3 ± 8.4	984.6 ± 20.8
Summer	802.2 ± 9.3	1083.5 ± 22.9
CD(p=0.05)	**	**

Carrying capacity of pasture systems:

The mean carrying capacity of hortipasture system is 8.1 sheep ha^{-1}, and of silvipasture system is 5.5 sheep ha^{-1}(Fig.3). The carrying capacity of hortipasture system is found higher compared to that of silvipasture system. The variation in carrying capacity is due to the variation in the annual above ground biomass produced per hectare. The biomass production per unit area decides the number of animals that can be allowed for grazing in the pasture systems (Sharma (2003). Seasonal variations were found in the production of biomass which then reflected on the carrying capacity of sheep per hectare of pasture system. Generally, the biomass production in hortipasture system was found more during different seasons compared to that of silvipasture system. Based on this, the carrying capacity of 10.74 sheep ha^{-1} was calculated for Kharif season under the hortipasture system and 7.3 sheep ha^{-1} for silvipasture system. The lowest carrying capacity was during winter season (5.40±0.0012 sheep ha^{-1} and 4.1± 0.0063 sheep ha^{-1}) during hortipasture and silvipasture system respectively. It was evident that the carrying capacity varies from place to place, system to system and season to season due to the biomass production at different rates. In case of cattle, the carrying capacity varied from the minimum of 1.54 to the maximum of 2.43 ha^{-1}. This is evident from the findings of Sharma (2003) and Devi (2005).



Water use efficiency of pasture systems: Higher water use efficiency was recorded under hortipasture system than silvipasture system (Fig.4). Water use efficiency obtained during summer season was highest during summer season (2.06 kg mm^{-1}) under hortipasture system, whereas silvipasture system recorded 1.525 kg mm^{-1}. The lowest water use efficiency of 0.171 kg mm^{-1} was recorded under hortipasture system and 0.103 kg mm^{-1} was recorded under silvipasture system during the rabi season. Though the amount of rainfall recorded was higher during rabi season, the water use efficiency was found minimum. During the rabi season, the total quantity of rainfall was obtained on 41 rainy days, leading to higher moisture availability in the soil. Niu *et al*. (2022) stated that temporal variation in soil moisture can alter water use efficiency. As there are continuous water availability enhancing the soil moisture throughout the season could have limited the water use efficiency, irrespective of the higher biomass production, which is found similar during kharif season under silvipasture and hortipasture system where the amount of rainfall was received in 51 rainy days. This is in line with the findings of Liu *et al*. (2017). It is also evident that irrespective of the species available in grasslands, the water use efficiency varied from 0.21 – 3.04 as reported by Dhaulakhandi *et al.* (2000).



Conclusion

It is concluded that the major species in pastures belongs to graminacea family and the biomass production is altered with seasons. The mean carrying capacity of the hortipasture system is 8.1 sheep ha^{-1}, and of silvipasture system is 5.5 sheep ha^{-1}. The water use efficiency during summer season was found higher. Hence, based on the seasonal biomass, allowing sheep for pasturing will be beneficial to sustain the biomass and to improve the productivity of livestock.

References

1. Brown D (1954) Methods of Surveying and Measuring Vegetation. Commonwealth Agricultural Bureaux, Farnham, Buck, England. 164 p.

2. Calicioglu O, Flammini A, Bracco S, Bellu L, Sims R (2019) *The Future Challenges of Food and Agriculture*: *An Integrated Analysis of Trends and Solutions. Sustainability*. 11: 1.

3. Chen J, Luo Y, Xia J et al (2017) Warming Effects on Ecosystem Carbon Fluxes Are Modulated by Plant Functional Types. Ecosystems 20: 515–526. https://doi.org/10.1007/s10021-016-0035-6

4. De Boeck HJ, Dreesen FE, Janssens IA, Nijs I (2011) Whole system responses of experimental plant communities to climate extremes imposed in different seasons. N Phyt 189:806–817. https://doi.org/10.1111/j.1469-8137.2010.03515.x.

5. Devi AR (2005) Biodiversity, biomass dynamics, net primary production and carrying capacity of the grasslands of Thoubal District (Manipur). Final Report Submitted to UGC, New Delhi. 101 p.

6. Dhaulakhandi M, Rajwar GS and Kumar P (2000) Primary productivity and system transfer functions in alpine grassland of western Garhwal Himalaya. Trop Ecol 41(1): 99-101.

7. Germani Concenço, Patrícia Menegaz de Farias, Néstor Fabio Alzate Quintero, Fábio Schreiber, Leandro Galon, Michely Tomazi, Ivana Santos Moisinho, Mariane Camponogara Coradini, William Christofari Ceolin and André Andres (2017) 'Phytosociological Surveys in Weed Science: Old Concept, New Approach', Plant Ecology - Traditional Approaches to Recent Trends. InTech doi: 10.5772/intechopen.69083.

8. Hossain ML, Beierkuhnlein C (2018) Enhanced aboveground biomass by increased precipitation in a central European grassland. *Ecol Process* **7 :** 37 https://doi.org/10.1186/s13717-018-0149-1.

9. Jentsch A, Kreyling J, Apostolova I, Bahn M, Bartha S, Beierkuhnlein C et al (2014) Joining biodiversity experiments, climate change research and invasion biology to assess European gradients of grassland resilience in the face of climate extremes. In: Mucina L, Price JN, Kalwij JM (eds) Biodiversity and vegetation: patterns, processes, conservation. Kwongan Foundation, Perth -114.

10. Kahmen A, Perner J, Buchmann N (2005) Diversity dependent productivity in semi-natural grasslands following climate perturbations. Func. Ecol 19:594 601. https://doi.org/10.1111/j.1365-2435.2005.01001.x.

11. Kohli RK, Dogra KS, Batish DR, Singh HP (2004) Impact of invasive plants on the structure and composition of natural vegetation of northwestern Indian Himalayas. Weed Technol 18:1296-1300.

12. Liu H J, Wang X M, Zhang X, Zhang L W, Li Y and Huang G (2017) Evaluation on the responses of maize (Zea mays L.) growth, yield and water use efficiency to drip irrigation water under mulch condition in the Hetao irrigation District of China Agric Water Manag 179: 144–157. doi: 10.1016/j.agwat.2016.05.031.Miranda Meehan, Kevin K Sedivec, Jeff Printz, Fara Brummer (2018) Determining Carrying Capacity and Stocking Rates for Range and Pasture in North Dakota R1810.

13. Nair PR, Nair VD (2014) Solid–fluid–gas' the state of knowledge on carbon-sequestration potential of agroforestry systems in Africa, Curr Opin Environ Sustain. 6: 22-27.

14. Niu L, Wang Z, Zhu G, Yu K, Li G, Long H (2022) Stable Soil Moisture Improves the Water Use Efficiency of Maize by Alleviating Short-Term Soil Water Stress. Front Plant Sci Apr 18;13:833041. doi: 10.3389/fpls.2022.833041.

15. Sachin Kumar, Surinder Singh Rana, Neelam Sharma, Rana Khalid Iqbal, Huma Qureshi, Tauseef Anwar, Asad Syed, Abdallah M. Elgorban, Rajalakshmanan Eswaramoorthy (2023) Weed phyto-sociology and diversity in relation to conservation agriculture and weed management strategies in Northwestern Himalayas of India, Journal of King Saud University - Science, 35 (6) :102728, ISSN 1018-3647, https://doi.org/10.1016/j.jksus.102728.

16. Sharma HM (2003) Vegetation dynamics and net primary production of the grassland ecosystem at Porompat (Imphal East District), Manipur. Ph.D. Thesis, Manipur University, Canchipur, Manipur (India). 166 p.

17. Travlos IS (2013) Competition between ACCase-Inhibitor Resistant and Susceptible Sterile Wild Oat (Avena sterilis) Biotypes. Weed Science. 61(1):26-31. doi:10.1614/WS-D-12-00065.1.