Professional Agricultural Workers Journal

Volume 7
Number 1 *Professional Agricultural Workers Journal (PAWJ)* 10

10-1-2019

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PRODUCTION PERIOD OF DIFFERENT BROWSE SPECIES SUITABLE FOR GRAZING SMALL RUMINANTS

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Abstract

Browse (shrubs, trees, and vines) species are important sources of feed for small ruminants in Alabama and many other states of the U.S. Information on the production period of these species is important to prepare a year-round grazing plan to utilize them well. The objective of the study was to determine the leaf-shedding time of common browse species suitable for small ruminants. This study was conducted at the Atkins Agroforestry and Browse Research and Demonstration Site of Tuskegee University, Alabama. Ten samples of each browse species were tagged, and leaf-yellowing and leaf-fall data collected using photoplots every 14 days until all leaves were shed. Out of 31 species studied, four were early shedders and four were evergreen species. The variation in leaf-shedding time among browse species can be useful for selecting suitable species to incorporate into the grazing systems and utilizing them well.

Keywords: Browse Species, Leaf-Shedding, Leaf-Yellowing, Grazing, Small Ruminants

Introduction

Browse includes leaves, shoots, sprouts, tender twigs, and stems of woody plants that are consumed by livestock to meet their dietary requirements (Gutteridge and Shelton, 1993). Several studies have highlighted the importance of browse for raising small ruminants for supplementing their diet, increasing diet variety, expanding the grazing opportunity, and minimizing the internal parasite problems (Karki, 2017). Also, the southeastern U.S. is known for having several browse species in its habitat. Therefore, small ruminant production systems in the region should take advantage of this habit (Addlestone et al., 1998), in order to raise market- ready goats. To fully utilize the browse species available in different grazing systems, information on the production period of these species is essential for small ruminant producers. There is a lack of information about the production period of common browse species available in the grazing lands of the southeastern U.S.

Most goat producers in Alabama have an average herd size of 18 goats and are referred to as resource poor farmers (Karki et al., 2011). These producers, including other small-scale goat producers in the Southeast depend on seasonal grasses to feed their animals (Karki, 2013a). However, browse species play a vital role in providing feed and nutrition requirement of small ruminants, especially energy, proteins, minerals, and vitamins during dry period of the year (Ouédraogo-Koné, 2008). Browse represents at least 40% of goats' diet in mixed Mediterranean environments (Landau et al., 2000). Solaiman (2006) reported that feeding cost is the single most significant variable cost involved in any livestock operation, which is equally applicable in the case of goats. Karki (2013b) reported that feeding cost can be reduced by extending grazing opportunity. Goats select tree, shrubs, forbs, flowering parts, seeds, and nuts that are rich in nutrients and secondary compounds when available. Browse not only helps in supplementing feed and sustain grazing animals' performance, but also helps in reducing internal parasite problems (Karki, 2017). Thus, in order to expand grazing opportunities, reduce feeding costs, and protect animals from gastrointestinal parasites, information on the production period of browse species is

necessary to utilize them efficiently and integrate into grazing systems. Therefore, the objective of the study was to determine the leaf-shedding time of common browse species suitable for small ruminants.

Literature Review

In the Karki (2017) study, goats ate a variety of available vegetation within their reach from ground level up to 6.4 feet in woodlands and removed 50 to 75% of the understory vegetation, showing potential to utilize available resources sustainably to produce valuable animal products and reduce the fuel build-up. Twenty-six browse species were readily consumed by goats when 37 major plant species were available in the Atkins Agroforestry Research and Demonstration Site, Tuskegee University, Tuskegee, Alabama, in May-July and September-October 2015 (Karki, 2017). Wild plum (*Prunus americana* Marshall) and winged elm (*Ulmus alata* Michx.) were the most preferred species. These contained a good amount of condensed tannin, showing their potential to minimize the problem of internal parasites in goats when incorporated into the grazing system (Karki, 2017). Among 16 browse plants (major sources of deer forage) studied in southern forests, twig elongation stopped for 12 species after rapid growth in spring, but few species grew through summer and two continued in the fall while most vines were found dead in late summer and fall (Halls, 1965).

In terms of fruiting, 11 species developed fruits in the fall, while the remaining species fruited in the summer (Halls, 1965). Dogwood (*Cornus florida* L.) continued to grow until October but growth after May was due to the formation of new twigs, but not because of the elongation of twigs that had developed earlier (Halls, 1965). The leaves of an evergreen browse species, yaupon, is important because of its high protein content throughout the year and being available for winter browsing (Blair and Halls, 1968). Yaupon (*Ilex vomitoria* Aiton), one of the major sources of deer food found in upland pine and hardwood mixed forest of the southern U.S., has two flush growths. One occurs in May and the other in early August, which continues until late October (Blair and Halls, 1968).

Khatri et al. (2016) observed that the diversity, evenness indices, vegetation cover at the ground, mid-level, and high level were reduced while cover with litter and bare ground increased after grazing with goats in woodland. The overall decrease in vegetation cover after grazing, without including plant debris and bare ground at the ground level, was 50% and reduction in vegetation cover was 46% at the mid-level and 3% at the high level. Blackberry, yaupon, and greenbrier were the dominant species before grazing and were reduced the most after grazing by goats. These authors highlighted that grazing with goats can have a significant short-term effect on plant species communities and biodiversity in woodland up to 5-feet height. These findings indicate that browse species available at different strata in the grazing systems are important feed sources for goats.

Mimosa (*Albizia julibrissin* Durazz.) is a leguminous tree that can provide good quality forage for small ruminants and can be incorporated into grazing systems (Addlestone et al., 1998). In summer, bush indigo (*Amorpha fruticosa* L.) also produces a high-quality forage (Papachristou et al., 1999). Information on production period and canopy development of different browse species is very important for small ruminant producers to utilize them efficiently. Leaves and twigs of browse species were important food sources for deer in the loblolly-short-leaf pine (*Pinus taeda* L.) forest of the South. According to Short et al. (1975), during the spring, twigs grew rapidly and were more succulent, nutritious, and digestible, but increased fiber content and reduced

digestibility occurred when they matured in the early summer. Also, browse leaves of evergreen species possess a good forage quality and digestibility for a whole year.

Goat grazing under semi-extensive production systems based on the shrub understory of a pine forest in the Doñana National Park, (Southwestern Spain) revealed that the consumption of shrub species varied, grazing did not follow a fixed pattern, and goats tended to select the leaves and shoots in all species, as well as dry and fleshy fruits (Mancilla-Leytón et al., 2012). Torres (1983) reported that woody perennials not only provide supplementary feeds in dry seasons in semi-arid and arid zones, certain species also promote pasture growth through soil enrichment. Therefore, animal agroforestry research needs to focus on pod-bearing trees that have beneficial effects both on understory growth and browsing system. Salem and Smith (2008) concluded that the easy and efficient way of fulfilling nutrient requirements of animals is by integrating browse species in woodlands; this can also reduce negative impacts of secondary compounds in goats and sheep. Despite the information reported in the literature regarding browse species, data on the duration of browse production in the Southeast is lacking. The knowledge of browse production patterns and time periods when the browse foliage is available for feeding animals is important to sustainably manage browse-based animal production systems.

Methods

Study Site

The study was conducted in two sections of the Research and Demonstration Site, Tuskegee University, Tuskegee, Alabama, USA, respectively, Agroforestry (seven acres) (32°26’35.7” N 85°43’56.5” W) (Figure 1) and Browse (13 acres) (32°26’00.7” N 85°43’00.2” W) (Figure 2). The soil in the Agroforestry section was Cowarts loamy sand (5-15% slopes) (80% of the total area) and Uchee-loamy sand (1-5% slopes) (20% of the total area). The Browse section contained Cowarts loamy sand (5-15% slopes) (95% of the total area) and Marvyn loamy sand (2-5% slopes) (5% of the total area) (USDA-NRCS, 2017). The Agroforestry section consisted of pine and hardwood trees and different types of shrubs, vines, and herbaceous vegetation. The Browse section had diverse browse species, both spontaneous and planted, and cultivated herbaceous species.

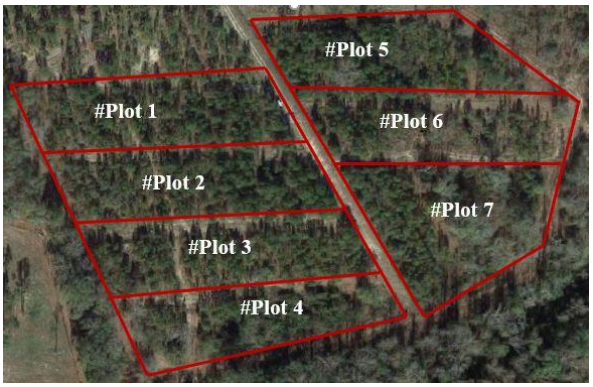

Figure 1. Research plots included in the study, Atkins Agroforestry Research and Demonstration Site, Tuskegee University, Tuskegee, Alabama, USA

Figure 2. Browse Research and Demonstration Site, Tuskegee University, Tuskegee, Alabama, USA

Data Collection

All browse species present in each section and having five or more replicates were identified and tagged with colored ribbon in the beginning of fall 2018. When enough plants were present, 10 observations per species in each section were marked for observation. A vertical photoplot (7'x2') that was divided into 56 squares (6"x 6") was installed by the tagged plants and pictures taken. The proportion of leaves that were yellowing (the stage prior to shedding) and the proportion of shed leaves on the tagged plants that were present within the photoplot were estimated and recorded on pre-formatted data sheets, using a scale ranging from 0 to 100%. Pre-formatted data sheets consisted of serial number, observation date, browse species, sample number, leaf-yellowing percentage, and leaf-shedding percentage. Observations were repeated every 14 days, beginning on October 15 and ending on December 31, 2018.

Data Analysis

The leaf-yellowing and shedding data were analyzed for correlation in SAS 9.4. Because they were found highly correlated, both variables were analyzed as one data set using GLM procedure with MANOVA option in SAS 9.4 to account for the significant correlation.

Results and Discussion

There were 31 browse species included in the study. Leaf-yellowing and shedding pattern of these browse species were highly correlated ($r=0.96$, $p<0.0001$), indicating that yellowing is the preceding stage for leaf fall. Four browse species: American beautyberry (*Callicarpa americana* L.), grapevine (*Vitis aestivalis* Michx.), rivercane (*Arundinaria gigantean* (Walter) Muhl.), and smallflower morningglory (*Jacquemontia tamnifolia* (L.) Griseb) showed 84-92% yellow leaves by October 15, implying that they would shed leaves soon after that (Table 1). All leaves of these species turned yellow by the end of November. Seven species had more than 90% of their leaves turned yellow by the end of November, and 16 more species reached that stage by the end of December. The leaf-yellowing timeframe of browse species included in the current study can be used as a guideline to estimate the imminent leaf fall and develop a timeline for utilizing the foliage

without jeopardizing the food storage required for plants during dormancy and vigorous regrowth in the next production season.

Table 1. Leaf-yellowing pattern of different browse species, Fall 2018, Agroforestry and Browse Sections, Research and Demonstration Site, Tuskegee University, Tuskegee, AL, USA

Plant species	Observation date					
	Oct.15	Oct. 30	Nov. 15	Nov. 30	Dec. 15	Dec. 30
	Leaf-yellowing (%, LSMeans±SE)					
American beautyberry (*Callicarpa americana* L.)	88±3.5	93±3.3	97±3.3	100±3.3	100±3.3	100±3.3
Bartlett pear (*Carya illinoinensis* (Wangenh.)	2±3.3	2±3.3	26±3.3	81 ±3.3	93±3.3	98±3.3
Blackberry (*Rubus* spp. L.)	6±2.3	7±2.3	16±2.3	38 ±2.3	67±2.3	84±2.3
Bush indigo (*Amorpha fruticosa* L.)	9±3.3	55±3.3	68±3.3	100±3.3	100±3.3	100±3.3
Chinaberry (*Melia azedarach* L.)	-	6±3.3	44±3.3	79±3.3	95±3.3	100±3.3
Chinese privet (*Ligustrum sinensis* Lour.)	0±3.3	1±3.3	11±3.3	26±3.3	55±3.3	78±3.3
Dogwood (*Cornus* spp. L.)	-	11±4.7	25±4.7	38±4.7	60±4.7	79±4.7
Gallberry (*Ilex coriacea* (Pursh) Chapm.)	5±3.3	7±3.3	12±3.3	27±3.3	42±3.3	58±3.3
Grapevine (*Vitis aestivalis* Michx.)	87±3.3	91±3.3	94±3.3	100±3.3	100±3.3	100±3.3
Greenbrier (*Smilax* spp. L.)	13±2.3	13±2.3	29±2.3	55±2.3	82±3.3	93±2.3
Hackberry (*Celtis occidentalis* L.)	-	16±4.7	32±4.7	70±4.7	88±4.7	95±4.7
Hickory (*Carya tomentosa* (Lam.) Nutt)	23±2.3	29±2.3	61±2.3	85±2.3	94±2.3	98±2.3
Honeysuckle (*Lonicera subspicata* Hook. & Arn)	1±3.3	3±2.3	19±2.3	44±2.3	72±2.3	89±2.3
Kudzu (*Pueraria montana* (Lour.) Merr.)	-	4±3.3	31±3.3	70±3.3	88±3.3	95±3.3
Laurel cherry (*Prunus caroliniana* Aiton)	-	1±4.7	9±4.7	23±4.7	42±4.7	65±4.7
Mimosa (*Mimosa borealis* A. Gray)	2±3.3	10±3.3	32±3.3	58±3.3	87±3.3	98±3.3
Pecan (*Carya illinoinens*is (Wangenh.) K. Koch)	-	7±3.3	37±3.3	70±3.3	89±3.3	95±3.3
Peppervine (*Nekemias arborea* (L.) J. Wen and Boggan)	-	17±3.3	43±3.3	71±3.3	84±3.3	92±3.3
Persimmon (*Diospyros virginiana* L.)	-	82±3.3	87±3.5	93±3.3	96±3.3	99±3.3
Red cedar (*Juniperus virginian*a L.)	-	6±4.7	24±4.7	35±4.7	64±4.7	70±4.7
Rivercane (*Arundinaria gigantean* (Walter) Muhl.)	92±3.3	94±3.3	97±3.3	100±3.3	100±3.3	100±3.3
Smallflower morningglory (*Jacquemontia tamnifolia* (L.) Griseb)	84±3.3	89±3.3	92±3.3	100±3.3	100±3.3	100±3.3
Southern red oak (*Quercus falcate* Michx.)	20±2.3	26±2.3	50±2.3	72±2.3	89±2.3	95±2.3
Sparkle berry (*Vaccinium arboreum* Marshall)	62±3.3	63±3.3	71±3.3	79±3.3	89±3.3	96±3.3
Sweetgum (*Liquidambar styraciflua* L.)	32±3.5	43±3.3	63±3.3	76±3.3	89±3.3	96±3.3
Water oak (*Quercus nigra* L.)	17±2.3	38±2.3	54±2.3	66±2.3	86±2.3	93±2.3
Wild plum (*Prunus americana* Marshall)	-	14±2.7	60±2.7	78±2.7	90±2.7	98±2.7
winged elm (*Ulmus alata* Michx)	10±3.3	43±2.3	68±2.3	92±2.3	97±2.3	100±2.3
Wisteria (*Wisteria frutescen*s (L.) Poir)	-	1±3.3	19±3.3	48±3.3	79±3.3	94±3.3
Yaupon (*Ilex vomitoria* Aiton)	7±3.3	9±3.3	22±3.3	32±3.3	50±3.3	60±3.3
Yellow jasmine (*Gelsemium sempervirens* L.)	-	31±3.3	45±3.3	66±3.3	80±3.3	90±3.3

The leaf-shedding pattern of browse species found in the study site is presented in Table 2. Four species (American beautyberry, grapevine, rivercane, and smallflower morningglory) shed a significant amount of their leaves (67-83%) by the end of October. Based on their early leaf-shedding pattern, they can be categorized as the early shedders and an appropriate grazing

Table 2. Leaf-shedding pattern of different browse species, Fall 2018, Agroforestry and Browse Sections, Atkins Research and Demonstration Site, Tuskegee University, Tuskegee, AL, USA

Plant species	Observation date					
	Oct. 15	Oct. 30	Nov. 15	Nov. 30	Dec. 15	Dec. 30
	Leaf-shedding (%, LSMeans±SE)					
American beautyberry (*Callicarpa americana* L.)	67±3.1	81±3.0	89±3.0	100±3.0	100±3.0	100±3.0
Bartlett pear (*Carya illinoinensis* (Wangenh.)	0±3.0	0±3.0	14±3.0	58±3.0	77±3.0	86±3.0
Blackberry (*Rubus* spp. L.)	1±2.1	2±2.1	8±2.1	23±2.1	52±2.1	69±2.1
Bush indigo (*Amorpha fruticosa* L.)	1±3.0	45±3.0	58±3.0	100±3.0	100±3.0	100±3.0
Chinaberry (*Melia azedarac*h L.)	-	3±3.0	34±3.0	69±3.0	83±3.0	100±3.0
Chinese privet (*Ligustrum sinensis* Lour.)	0±3.0	0±3.0	6±3.0	15±3.0	39±3.0	57±3.0
Dogwood (*Cornus* spp. L.)	-	4±4.2	13±3.0	24±4.2	40±4.2	62±4.2
Gallberry (*Ilex coriacea* (Pursh) Chapm.)	1±3.0	2±3.0	6±3.0	17±3.0	27±3.0	41±3.0
Grapevine (*Vitis aestivalis* Michx.)	68±3.0	77±3.0	84±3.0	100±3.0	100±3.0	100±3.0
Greenbrier (*Smilax* L.)	2±2.1	3±2.1	15±2.1	37±2.1	65±3.0	82±2.1
Hackberry (*Celtis occidentalis* L.)	-	8±4.2	21±4.2	61±4.2	75±4.2	85±4.2
Hickory (*Carya tomentosa* (Lam.) Nutt)	3±2.1	6±2.1	23±2.1	65±2.1	80±2.1	88±2.1
Honeysuckle (*Lonicera subspicata* Hook. & Arn)	0±3.1	1±2.1	11±2.1	28±2.1	54±2.1	72±2.1
Kudzu (*Pueraria montan*a (Lour.) Merr.)	-	1±3.0	22±3.0	60±3.0	75±3.0	86±3.0
Laurel cherry (*Prunus caroliniana* Aiton)	-	1±4.2	3±4.2	13±4.2	26±4.2	47±4.2
Mimosa (*Mimosa borealis* A. Gray)	0±3.0	4±3.0	20±3.0	45±3.0	76±3.0	91±3.0
Pecan (*Carya illinoinensis* (Wangenh.) K. Koch)	-	2±3.0	26±3.0	54±3.0	76±3.0	83±3.0
Peppervine (*Nekemias arborea* (L.) J. Wen and Boggan)	1±3.0	9±3.0	30±3.0	56±3.0	71±3.0	77±3.0
Persimmon (*Diospyros virginiana* L.)	-	29±3.0	48±3.1	74±3.0	83±3.0	86±3.0
Red cedar (*Juniperus virginiana* L.)	-	2±4.2	12±4.2	22±4.2	46±4.2	54±4.2
Rivercane (*Arundinaria gigantean* (Walter) Muhl.)	83±3.0	86±3.0	90±3.0	100±3.0	100±3.0	100±3.0
Smallflower morningglory (*Jacquemontia tamnifolia* (L.) Griseb.)	69±3.0	82±3.0	84±3.0	100±3.0	100±3.0	100±3.0
Southern red oak (*Quercus falcat*e Michx.)	4±2.1	10±2.1	29±2.1	56±2.1	75±2.1	84±2.1
Sparkle berry (*Vaccinium arboreum* Marshall)	12±3.0	16±3.0	36±3.0	63±3.0	76±3.0	84±3.0
Sweetgum (*Liquidambar styraciflua* L.)	7±3.1	17±3.0	35±3.0	59±3.0	71±3.0	83±3.0
Water oak (*Quercus nigra* L.)	4±2.1	21±2.1	34±2.1	51±2.1	70±2.1	78±2.1
Wild plum (*Prunus americana* Marshall)	-	6±2.4	43±2.4	64±2.4	76±2.4	89±2.4
Winged elm (*Ulmus alata* Michx)	2±3.0	27±2.1	52±2.1	74±2.1	85±2.1	93±2.1
Wisteria (*Wisteria frutescens* (L.) Poir)	-	0±3.0	11±3.0	33±3.0	59±3.0	79±3.0
Yaupon (*Ilex vomitoria* Aiton)	2±3.0	3±3.0	10±3.0	19±3.0	36±3.0	45±3.0
Yellow jasmine (*Gelsemium sempervirens* L.)	-	7±3.0	19±3.0	50±3.0	64±3.0	75±3.0

plan needs to be scheduled to utilize their foliage much in advance of the incidence of yellowing and shedding. The early shedders lost most of their leaves (84-90%) by November and all leaves by mid-December. Eleven species had 50% or more leaves still intact by the end of November, indicating that these species can be targeted for early to mid-fall grazing.

There were four evergreen species, gallberry (*Ilex coriacea* (Pursh) Chapm.), laurel cherry (*Prunus caroliniana* Aiton), red cedar (*Juniperus virginiana* L.), and yaupon (*Ilex vomitoria* Aiton), with significant amounts of intact leaves (46-59%) by the end of December. This finding provides an insight that even the evergreen species shed a substantial amount of their leaves during fall, especially late in the season. Other few, very commonly available species, such as blackberry (*Rubus* L.), Chinese privet (*Ligustrum sinensis* Lour.), dogwood (*Cornus florida* L.), and honeysuckle (*Lonicera subspicata* Hook. & Arn) were found to bear a considerable amount of intact leaves (46-61%) by mid-December, presenting themselves as valuable browse species for fall grazing.

Conclusion

The leaf-yellowing and shedding pattern of browse species showed a very high correlation, suggesting that leaf-yellowing is the indication of imminent leaf fall. The timeframe of leaf-yellowing and shedding of browse species greatly varied. Three important species for small ruminants (American beautyberry, grapevine, and rivercane) began these processes early in the season and lost all leaves before the end of the season. Four evergreen species (gallberry, laurel cherry, red cedar, and yaupon), and four late shedding species (blackberry, Chinese privet, dogwood, and honeysuckle) identified in the current study can be very valuable feed sources for small ruminants during fall. The findings of the study can serve as valuable guidelines for developing suitable grazing/browsing plans for sustainable management of browse species present in grazing systems. Further studies are needed to find out the sprouting and canopy development pattern of these browse species and determine the beginning of grazing/browsing time.

Acknowledgement

This study was funded by USDA-NIFA-AFRI Grant Number 2016-68006-2476 and McIntire-Stennis Forestry Research Program.

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