DOI: https://doi.org/10.29298/rmcf.v10i51.201

Article

Eficiencia en la cosecha manual de follaje de moté (*Erythrina americana* Miller)

Efficiency on manual harvest of *mote* (*Erythrina americana* Miller) foliage

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Resumen:

El moté (*Erythrina americana*) es un árbol caducifolio considerado como especie multiusos de la familia Fabaceae; está ampliamente distribuido en la región tropical de México, y por su contenido de proteína cruda y carbohidratos estructurales en las hojas, se ha convertido en un recurso atractivo como complemento alimenticio para pequeños rumiantes como los ovinos. Sin embargo, existen pocos estudios relativos a la eficiencia en la cosecha manual de follaje en plantaciones que no han recibido manejo previo. Por lo tanto, se llevó a cabo un estudio durante la época climática de nortes, en el que se siguió un diseño completamente al azar, para conocer la influencia del técnico-cosechador sobre la eficiencia de cosecha de follaje de *E. americana.* De este material se determinaron materia seca, cenizas, materia orgánica, proteína cruda, fibra detergente neutro y fibra detergente ácido. Las variables evaluadas fueron: follaje y ramas cosechadas (kg) en una y tres h (en base húmeda y seca), relación follaje ramas^{-1} y proteína cruda. Los resultados indican una amplia variación en la cosecha de follaje (41 % de CV), pero el técnico-cosechador no afectó (p>0.05) ninguna de las variables estudiadas. En cercos vivos de *E. americana* sin manejo previo de poda, este agente no tuvo ningún efecto.

Palabras clave: Árbol multiusos, follaje, forraje, ovinos, silvopastoril, trópico húmedo.

Abstract:

Moté (*Erythrina americana* Miller) is a deciduous tree of the family Fabaceae widely distributed in the Mexican tropical region whose foliage can be incorporated into programs of sheep feeding. However, there are few studies on the efficiency of the manual harvest of foliage in plantations which have not received previous management. The aim of the study was to determine the influence of the technician-harvester on the efficiency of foliage harvest of *E. americana*. A completely random design was used, where the study factor was the technician-harvester (four harvesters). The process of pruning and manual harvest of foliage was carried out during the north winds season. In the foliage, dry matter, ashes, organic matter, crude protein, neutral detergent fiber and acid detergent fiber were determined. The evaluated variables were: harvested foliage and branches (kg) in one and three hours (on wet and dry basis), foliage branches^{-1} ratio and crude protein obtained from harvested foliage. Wide variation was detected in the foliage harvest (41 % of CV). The technician-harvester did not affect (p> 0.05) any of the variables studied. In live fences with *E. americana* without previous pruning management, the technician-harvester did not influence the efficiency of foliage harvesting.

Key words: Multipurpose tree, foliage, forage, sheeo, forestry humid tropic

Fecha de recepción/Reception date: 2 de febrero de 2018
Fecha de aceptación/Acceptance date: 29 de noviembre de 2018

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Introduction

Erythrina americana is an arboreal legume considered as a multipurpose tree (García *et al*., 2001; Villanueva *et al.*, 2015). It has been proposed as a forest restorer, especially those located in the tropical region with a dry season (Fehling and Ceccon, 2015), the ethnomedical use of its flowers and seeds has been documented in Mexico (García *et al.,* 2001; Pino *et al.,* 2004; Sotelo *et al*., 2007); in livestock farming it is used as part of the fence (live pole), which, additionally, provides shade and firewood, and it works ass as a windbreak curtain (Grande *et al.,* 2013; Oliva *et al.,* 2013).

The content of crude protein and structural carbohydrates in the foliage of *E. americana* make its use attractive as a food supplement for small ruminants (Benavides, 1999; Grande, 2010). Particularly, sheep easily consume the foliage of the species and thus, can be incorporated in their diet up to 30% (Pinto *et al.,* 2003, Best *et al.,* 2017). This legume produces foliage all year round when it receives controlled pruning (Meléndez, 2003), and it can be established during that period (Enríquez *et al*., 2011).

E. americana grows in the states of *Puebla, Veracruz, Tabasco*, *Chiapas* and *Yucatán* (Llera and Mélendez, 1994) and is often located in livestock production units (Reyes and Jiménez, 1998; Grande, 2010), a situation that facilitates the acquisition of vegetative material for its propagation. Despite its wide distribution in the tropical region of Mexico, there are few studies on the yield of foliage per tree (Meléndez, 2003, Oliva-Hernández and López-Herrera, 2017) and the efficiency of manual harvest of the leaves in trees that have not had previous pruning is unknown. Therefore, the objective of the present study was to determine the influence of the harvester-technitianon the efficiency in manual harvesting of *E. americana* foliage that is part of the live fence.

Materials and Methods

Study area

Field work was carried out during the hurricane season (December) in the live fences of the *Unidad Ovina Experimental del Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias* (Experimental Ovine Unit of the National Forestry, Agriculture and Livestock Research Institute,) located in *Huimanguillo* municipality, *Tabasco* State (17°50' N, 93°23' O), with humid warm climate, rain all year round (Af) and average annual temperature of 27.8 °C (Inegi, 2017).

Harvest of foliage and branches

Twelve trees with no previous pruning of branches were used, which were planted as trunks between 2009 and 2014. The cutting of branches and foliage harvesting of *E. americana* was manual and with machete, saw and pruning tweezers. Once the branches were cut, the foliage was separated, which included leaves and petioles and not the tender stems. The foliage and branches were weighed green (wet basis) separately, with a platform scale with a capacity of 500 kg and a sensitivity of 200 g (Oken®).

The collection was performed by four harvest- technicians, three men and one woman. Harvester one (man) had experience in field work, and the other three did not, nor in the manual process of foliage harvest of the species of interest. Foliage and branches were collected for three hours, between 9:00 and 12:00 h, after which the activity stopped; therefore, the collection was total in some trees and partial in others.

To obtain the foliage quality of *E. americana*, eight samples of the foliage were taken at random during the study period and, in duplicate, dry matter (DM), ash, organic matter and crude protein with AOAC methods (2005); fractions of neutral detergent fiber and acid detergent fiber with the techniques of Van Soest *et al*. (1991) were determined.

The amount of harvested foliage by each technician in one hour was calculated with the formula:

$$FCBH\_1h = \frac{[\mathrm{FCBH\_3}h\ (\mathrm{kg})]}{3}$$

Where:

FCBH_1h = Harvested foliage in wet basis in one hour

FCBH_3h = Harvested foliage in wet basis in three hours

For the harvested branches (kg) in one hour the same formula previously described for the *FBHC_1h* was used, in which the weight of the foliage was replaced by that of the branches.

The foliage harvested on a dry basis (BS) in one hour was calculated with the equation:

$$FCBS\_1h = \frac{[FCBH\_3h\ (\mathrm{kg}) * \mathrm{MSF}/100]}{3}$$

Where

FCBS_1h = Harvested foliage in dry basis in one hour

FCBH_3h = Harvested foliage in dry basis in three hours

MSF = Dry matter of foliage

The foliage branches^{-1}relation was calculated as follows:

$$FR = \frac{FCBH\_3h\ (\mathrm{kg})}{RC\_3h(\mathrm{kg})}$$

Where:

FR = Foliage branches^{-1}relation

FBH = Foliage in wet basis

RC_3h = Harvested branches in three hours

The grams of raw foliage protein obtained by each technician in one and three hours were calculated with the formula:

$$PCFC = \frac{[\text{FCBS in "x" h (g)} * \frac{\text{PC\_F}}{100}]}{\text{number of "x" h}}$$

Where:

PCFC = Raw foliage protein harvested in “X” hours

FCBS = Harvested foliage in dry basis in “X” hours

PC_F = Raw foliage protein

Dependent variables

The dependent variables were: foliage and harvested branches (kg) in one and three hours (in wet and dry basis), foliage branches^{-1} ratio and crude protein obtained from the harvested foliage.

Experimental design and statistical analysis

A completely random design was used, whose factor was the technician-harvester. The experimental unit (UE) was the harvest period of three hours. Four UEs were used per harvester- technician. All analyzes were carried out with the statistical package SAS 9.0 (SAS, 2002). The data was analyzed with the Kruskal Wallis test.

When the influence of the treatment on the response variable was observed, the Wilcoxon interval range sum test was applied for unpaired data (Milton, 2007).

Results and Discussion

Table 1 shows the chemical composition of *E. americana* foliage. It is confirmed that the crude protein content was higher than that of tropical pastures (Enríquez *et al.,* 2011). However, the crude protein in the foliage was lower than that indicated by Reyes and Jiménez (1998) and Hernández-Espinoza *et al*. (2017), who indicate values between 15.4 and 25.6%. Differences in crude protein between studies can be attributed to the time of harvest and age of regrowth of the foliage (Benavides, 1999; Hernández-Espinoza *et al.,* 2017).

Table 1. Chemical composition of *moté* foliage (*Erythrina Americana* Miller) without previous history of pruning and foliage harvesting.

Component	**Number of components**	**Mean (%) ± SD**
Dey matter	8	22.4 ± 1.4
Organic matter	8	90.6 ± 0.5
Ashes[1]	8	9.4 ± 0.5
Crude protein[1]	8	14.5 ± 0.8
Neutral detergent fiber[1]	8	52.4 ± 3.5
Acid detergent fiber[1]	8	40.1 ± 1.7

[1]Percentage of dry matter

In regard to structural carbohydrates, Reyes and Jiménez (1998) indicate figures between 58.3 and 60.9 % for neutral detergent fiber and 41.9 to 41.4 % for acid detergent fiber, which are higher than what was recorded in this study for the neutral detergent fiber, and similar for the case of acid detergent fiber. The increase in the value of the first reduces the feed intake in ruminants. Depends on the state of maturity of the plant, when it is greater, so is neutral detergent fiber, hence the importance of determining the factors that affect its content in the foliage of trees with potential to be used as food for ruminants (Pinto *et al*., 2002; García, 2003).

The foliage of arboreal legumes is characterized by its attractive protein value (Pinto *et al*., 2002, 2003). However, it is important to consider that in this type of foliage there are secondary metabolites that protect the plant and help maintain balance in the plant-herbivore interaction (Ramos *et al.,* 1998).

In the *Erythrina* genus, a large number of secondary metabolites have been isolated in different parts of the plant (seeds, flowers, bark, leaves, roots), highlighting alkaloids (38 %), flavonoids (38 %) and proteoids (9 %) as families of chemical compounds that are cited with greater frequency (García *et al.,* 2001; Pino *et al.,* 2004; Ibarra *et al.,* 2011).

It is in the leaves of *Erythrina* that there are the fewest quantitative and qualitative studies to determine the presence of secondary metabolites. However, it has been determined that alkaloids (64 %), flavonoids (27 %) and triterpenoids (9 %) are the chemical families that have a higher frequency of presentation (Pino *et al*., 2004). In the foliage of *Erythrina goldmani*i Standley. Pinto *et al.* (2002, 2003) report the presence of total phenols (0.6 %) and condensed tannins (16.28 g kg^{-1} MS). Further studies are required to determine the influence of the level of inclusion of *E. americana* in the diet of ruminants on the productive behavior and state of health.

A wide variation was observed in the amount of foliage and branches harvested; the greatest variation corresponded to the foliage in relation to the branches (Table 2). The harvester-technician did not affect ($p > 0.05$) any of the variables studied. The wide variation detected in the harvested material between and within technicians contributed to explain the absence of differences between the collectors (Table 3). In this regard, García and Oliva (2012) studied a *cocoite* plantation (*Gliricidia sepium* (Jacq.) Kunth ex Walp.), with no background in the management of pruning and foliage harvesting; the authors point out an efficiency in the harvest of foliage of this species of 7.0 ± 2.7 kg h^{-1} on a humid basis and 2.3 ± 0.9 h^{-1} on a dry basis, results that are similar to what was recorded in the present study (Table 2) . Although the branches of *E. americana* have thorns, their presence was not a limitation in the manual harvest process; nevertheless, it was necessary to use raw-leather gloves to avoid injuries in the hand of the harvester.

Table 2. Indicators of *moté* foliage (*Erythrina Americana* Miller) and branches harvest in live fences for the shepp management.

Variable	**Number of components**	**Mean± SD**	**Minimum**	**Maximum**	**CV[1] (%)**
Foliage (wet basis)					
In three h (kg)	16	22.8 ± 9.3	10.6	40.6	41
In one h (kg)	16	7.6 ± 3.1	3.5	13.5	41
Foiage (dry basis)					
In three h (kg)	16	5.1 ± 2.1	2.4	9.1	41
In one h (kg)	16	1.7 ± 0.7	0.8	3.0	41
Branches (kg)					
In three h (kg)	16	76.3 ± 22.7	38.0	137.0	30
In one h (kg)	16	25.4 ± 7.6	12.9	45.7	30
Foliage-branches^{-1} ratio	16	0.30 ± 0.1	0.16	0.45	33
Crude protein obtained from the harvested foliage					
In three h (g)	16	740 ± 301	344	1319	41
In one h (g)	16	247 ± 100	115	440	41

[1]CV = Coefficient of variation

Table 3. Influence of the harvester-technician in the efficiency of the manual foliage harvest of *moté* (*Erythrina Americana* Miller) with no pruning or foliage harvest background.

Variable	Number of components	Hervester-Technitian			
		One (man)	Two (woman)	Three (man)	Four (man)
Foliage (WB)[1]					
In three h (kg)	4	31.6 ± 4.3	22.2 ± 4.3	22.5 ± 4.5	14.9 ± 1.7
In one h (kg)	4	10.5 ± 1.4	7.4 ± 1.5	7.5 ± 1.5	5.0 ± 0.6
Foliage (DB)[2]					
In three h (kg)	4	7.1 ± 1.0	5.0 ± 1.0	5.0 ± 1.0	3.3 ± 0.4
In one h (kg)	4	2.4 ± 0.3	1.7 ± 0.3	1.7 ± 0.3	1.1 ± 0.1
Branches (kg)					
In three h (kg)	4	80.4 ± 5.0	69.8 ± 8.8	88.5 ± 20.7	66.7 ± 2.9
In one h (kg)	4	26.8 ± 1.7	23.3 ± 2.9	29.5 ± 6.9	22.2 ± 1.0
Branch-foliage ratio	4	0.39 ± 0.04	0.31 ± 0.03	0.29 ± 0.07	0.22 ± 0.03
Crude protein from the harvested foliage					
In three h (g)	4	1026 ± 141	719 ± 141	732 ± 145	482 ± 54
In one h (g)	4	342 ± 47	240 ± 47	244 ± 48	161 ± 18

($P>0.05$); [1]WB = Wet basis; [2]DB = Dry basis

The foliage relationship branches^{-1} was lower than the one indicated by Oliva-Hernández and López-Herrera (2017) who declared a foliage relationship branches^{-1} between 2.0 and 3.2 in trees of *E. americana*, when the trees have been subjected to a process of pruning at 90 -day intervals. The lowest branch^{-1} foliage ratio detected in the present study is attributed to the greater weight and size of the branches, because the trees used had not been pruned.

In the study by García and Oliva (2012) it was determined that the crude protein in the *G. sepium* foliage was 23.6 %, and if it is considered that a harvester reached

2.3 kg of foliage on a dry basis h^{-1}, 543 g result of crude protein from *G. sepium*, which was higher than that obtained with *E. americana* (Table 2). The different crude protein content in the foliages of *G. sepium* and *E. americana* explains the contrast between studies.

On the other hand, there is evidence that the foliage of *E. indica* Lam can be incorporated into the diet of sheep by 30% in substitution to the use of soybean paste (Best *et al.,* 2017). A harvester produces 1.7 kg of foliage on dry basis h^{-1}, equivalent to 247 g of crude protein, this amount of protein covers 30% of the crude protein ingested by seven Pelibuey sheep with 20 kg of live weight that receive a complete diet with 2.8 Mcal of metabolizable energy kg of MS^{-1} and 19.8 % of crude protein (Pascual *et al.*, 2009).

The availability of *E. americana* foliage most of the year (Meléndez, 2003), the facility for its vegetative macropropagation compared with the sexual reproduction that requires scarified seeds to germinate (Fehling and Ceccon, 2015), its feasible presence as a live fence (Grande *et al.,* 2013; Oliva-Hernández and López-Herrera, 2017) and the amount of crude protein obtained from the foliage during a three-hour working day favors this food resource as an option to give sustainability to the production systems of sheep that use multipurpose trees as part of living fences.

Conclusions

The efficiency in harvesting foliage and branches in *E. americana* without previous pruning history is not affected by the technician-harvester, which indicates that specific training is not required to perform such activity, a situation that facilitates the collection of foliage for use as ruminant food. The content of crude protein and structural carbohydrates in the foliage of *E. americana* allows it to be considered an ingredient to complement the crude protein requirements of small grazing ruminants or to be part of integral diets.

Conflict of interests

The authors declare no conflict of interest.

Contribution by author

Jorge Oliva Hernández: study design, statistical analysis of the data and preparation of the manuscript; María Aurelia López Herrera: design of the study, chemical analysis of the foliar samples and review of the manuscript; Erika Velázquez Jiménez experimental data and review of the manuscript; Giovani López Enríquez experimental data and review of the manuscript; Irving Iván Vélez Pérez experimental data and review of the manuscript.

References

Association of Official Analytical Chemists (AOAC). 2005. Animal Feed. Official Methods of Analysis of AOAC International. 18th Ed. Gaithersburg, MA USA. pp. 1-35.

Benavides, J. 1999. Árboles y arbustos forrajeros: una alternativa agroforestal para la ganadería. *In*: Sánchez, M. D. y M. Rosales M. (eds.). Agroforestería para la Producción Animal en Latinoamérica. Organización de las Naciones Unidas para la Agricultura y la Alimentación. Roma, Italia. pp. 367-394. http://www.fao.org/livestock/agap/frg/agrofor1/bnvdes23.pdf . (2 de abril de 2017)

Best, D. A., P. E. Lara L., E. Aguilar U., F. E. Cen Ch., J. C. Ku V. and J. R. Sanginés G. 2017. *In vivo* digestibility and nitrogen balance in sheep diets with foliage of fodder trees in substitution for soybean meal. Agroforestry Systems 91 (6):1079-1085. doi:10.1007/s10457-016-9982-3.

Enríquez Q., J. F., F. Meléndez N., E. D. Bolaños A. y V. A. Esqueda E. 2011. Producción y manejo de forrajes tropicales. Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias. Libro técnico Núm. 28. Medellín de Bravo, Ver., México. 404 p.

Fehling F., T. C. and E. Ceccon. 2015. Macropropagation of *Erythrina americana* in a greenhouse: a potential tool for seasonally dry tropical forest restoration. Revista Chapingo Serie Ciencias Forestales y del Ambiente 21 (1): 5-16.

García, A., N. Thiex, K. Kalscheur and K. Tjardes. 2003. Interpreting Hay and Haylage analysis. Extension Extra. South Dakota State University. Brookings, SD USA. 3 p.

García M., R., M. Soto H. and H. Vibrans. 2001. *Erythrina americana* Miller ("Colorín": Fabaceae), a versatile resource from Mexico: A Review. Economic Botany 55(3):391-400.

García O., I. C. y J. Oliva H. 2012. Observaciones sobre la cosecha de follaje de cocoite para alimentar corderos en pastoreo. Kuxulkab' 18(34): 59-64.

Grande C., J. D. 2010. Los árboles forrajeros como recurso potencial para el desarrollo de sistemas silvopastoriles en la región de la sierra de Tabasco. Tesis Doctoral. Universidad Autónoma Metropolitana. México, D.F., México. 198 p.

Grande C., D., G. Villanueva L., N. M. Maldonado G. y S. Hernández D. 2013. Las cercas vivas. *In*: Maldonado G., N.M. (coordinador). Los sistemas silvopastoriles en Tabasco. Una opción para desarrollar una ganadería productiva y amigable con la naturaleza. Universidad Juárez Autónoma de Tabasco. Villahermosa, Tab., México. pp. 23-39.

Hernández-Espinoza, D. F., J. A. Ramos-Juárez, M. A. López-Herrera, I. del C. Lagunes-Espinoza, R. González-Garduño y J. Oliva-Hernández. 2017. Influencia de la edad de rebrote de *Erythrina americana* sobre la composición química del follaje. *In*: Martínez H., J. (coord.). XXIX Reunión Científica Tecnológica, Forestal y Agropecuaria Tabasco 2017 VI Simposio Internacional en Producción Agroalimentaria Tropical. Villahermosa, Tab., México. pp. 53-56.

Ibarra, E., E., M. Pacheco S., R. García, M., R. San Miguel Ch., G. Ramírez V. y R. M. Soto H. 2011. Actividad antioxidante de alcaloides de *Erythrina americana* Miller. Revista Fitotecnia Mexicana 34 (4): 241-246.

Instituto Nacional de Estadística y Geografía (Inegi). 2017. Anuario Estadístico Tabasco. Gobierno del estado de Tabasco, México. 443 p.

Llera Z., M. y F. Meléndez N. 1994. Establecimiento y manejo de cercos vivos en Tabasco. Instituto Nacional de Investigaciones Forestales y Agropecuarias. Folleto Técnico 14. Huimanguillo, Tab., México. 13 p.

Meléndez N., F. 2003. Arbustos Forrajeros para Tabasco. Manejo de Forrajes Tropicales en Tabasco. Instituto de Investigaciones Forestales, Agrícolas y Pecuarias, Instituto para el Desarrollo de Sistemas de Producción del Trópico Húmedo de Tabasco. Folleto Técnico. Villahermosa, Tab., México. pp. 29-31.

Milton, J. S. 2007. Estadística para biología y ciencias de la salud. Mc Graw-Hill Interamericana. Madrid, España. 722 p.

Oliva H., J., M. Barrón A., L. Granados Z. y J. Quiroz V. 2013. Crecimiento de corderos en pastoreo, limitantes y retos. Kuxulkab' 19(37): 13-18.

Oliva-Hernández, J. y M. A. López-Herrera. 2017. Relación entre características físicas del árbol *Erythrina americana* con la producción de follaje para la alimentación de ovinos. *In*: Martínez H., J. (coord.). XXIX Reunión Científica Tecnológica, Forestal y Agropecuaria Tabasco 2017 VI Simposio Internacional en Producción Agroalimentaria Tropical. Villahermosa, Tab., México. pp. 58-63.

Pascual C, A., J. Oliva H, D. Hernández S., G. Torres H., M. E. Suárez O. y J. A. Hinojosa C. 2009. Crecimiento postdestete y eficiencia reproductiva de corderas Pelibuey con un sistema de alimentación intensiva. Archivos de Medicina Veterinaria 41: 205-212.

Pino R-, S., S. Prieto G., M. E. Pérez R. y J. Molina T. 2004. Género *Erythrina*: Fuente de metabolitos secundarios con actividad biológica. Acta Farmacéutica Bonaerense 23: 252-258.

Pinto R., R., L. Ramírez A., J. C. Kú V. y L. Ortega R. 2002. Especies arbóreas y herbáceas forrajeras del sureste de México. Pastos y Forrajes 25 (3): 171-180.

Pinto, R., H. Gómez, A. Hernández, F. Medina, B. Martínez, V. H. Aguilar, I. Villalobos, J. Nahed y J. Carmona. 2003. Preferencia ovina de árboles forrajeros del Centro de Chiapas, México. Pastos y Forrajes 26 (4): 329-334.

Ramos, G., P. Frutos, F. J. Giráldez y A. R. Mantecón. 1998. Los compuestos secundarios de las plantas en la nutrición de los herbívoros. Archivos de Zootecnia 47: 597-620.

Reyes, M. F. y F. G. Jiménez. 1998. Uso y valor nutritivo de árboles y arbustos con potencial forrajero en la región de la sierra, Tabasco, México. *In*: Sánchez D., D del C., R. Jiménez de los S., N. del C. López A. y E. Gómez M. (eds.). XI Reunión Científica Tecnológica Forestal y Agropecuaria Tabasco 98. Villahermosa, Tab., México. pp. 73-80.

Statistical Analysis System (SAS). 2002. User´s Guide (Release 9.0). SAS Institute. Cary, NC USA. 956 p.

Sotelo, A., S. López G. and F. Basurto P. 2007. Content of nutrient and antinutrient in edible flowers of wild plants in Mexico. Plant Foods for Human Nutrition 62: 133-138.

Van Soest, P. J., J. D. Robertson and B. A. Lewis. 1991. Methods for dietary fiber, neutral detergent fiber and non-starch polysaccharides in relation to animal nutrition. Journal of Dairy Science 74: 3583-3597.

Villanueva L., G., P. Martínez Z. y H. Van der Wal. 2015. Árboles y arbustos en áreas ganaderas de Tabasco: un recurso prometedor. Ecofronteras 19 (54): 14-17.