Review of scientific and technical bibliography on the use of *Opuntia* spp. as forage and its animal validation

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ABSTRACT

Several studies have shown the remarkable properties of *Opuntia* spp., a largely distributed species in the world. It has been used as an edible resource, especially in periods of food shortage, and also as livestock food in arid lands. This review aimed at identifying current literature related to *Opuntia* spp. as forage and its validation through experiences with domestic and other animals. The literature review was carried out October 3, 2014 using the Scopus database. From 5,723 documents, 98 of them were selected, all of those which involved experiences with animals both in housing conditions and in extensive grazing. The following items were analyzed: publication year, document type, source title, author affiliation and country, source type, language, animal species used in the experiences and a particular analysis of the publications in the Journal of the Professional Association for Cactus Development according to Scopus. It was detected that Scopus omitted some documents in the review, and there were few contributions regarding experiences that include cactus as part of animal diets.

Keywords: *Opuntia* spp.*,* cactus, forage, animal nutrition.

RESUMEN

Varios estudios demuestran las interesantes propiedades de la *Opuntia* spp., ampliamente distribuida en el mundo, donde ha sido usada como recurso alimenticio especialmente en épocas de escasez de forrajes para alimentación del ganado en tierras áridas. Esta revisión tuvo como objetivo identificar la bibliografía existente en relación a la *Opuntia* spp. como forraje detectando las experiencias en que intervinieron animales. La búsqueda bibliográfica fue realizada el 3 de octubre de 2014 a través de la base de datos de Scopus. De 5.723 documentos fueron seleccionados 98 de ellos, los cuales involucraban experiencias con

animales tanto en condiciones de estabulación como en pastoreo extensivo. Los siguientes ítems fueron analizados: año de publicación, tipo de documento, revista en que fue publicado, lugar de trabajo y país del autor, tipo de fuente, idioma de publicación, especies animales usadas en las experiencias y un análisis de las publicaciones del Journal of the Professional Association for Cactus Development relevadas por Scopus. Fue detectado que Scopus no incorpora algunos documentos en la revisión y existen pocas contribuciones en relación a experiencias que incluyen cactus como parte de la dieta de animales.

Palabras clave: *Opuntia* spp.*,* cactus, forraje, nutrición animal.

INTRODUCTION

The biological diversity of countries, regions and ecosystems is formed by evolved native species that have lived in the area for thousands of years and are adapted to existing conditions (Ojasti, 2001).

Cacti have greater water-use efficiency due to the Crassulacean Acid Metabolism (CAM) photosynthetic pathway that is several times more efficient in converting water and CO_2 to dry matter plants than either C_4 or C_3 plants (Han and Felker 1997; Nobel 1991; Nobel, 1994) which makes them especially suited for forage production in arid lands.

Plantations of drought-tolerant and water-efficient fodder shrubs, especially *Opuntia* species, have been established as buffer feed reserves as a strategy to mitigate the effects of drought in animal production systems of various arid and semiarid zones of the world. In this strategy the buffer reserve was aimed not only as “drought insurance” for inter-annual drought but also to bridge up a recurrent annual period of feed scarcity (Le Houérou, 1991; Le Houérou et al., 1991).

Cactus is a widely distributed species in different parts of the world, in tropical and temperate regions, with the highest diversity of species occurring in Mexico. Some 2.6 million hectares are being cultivated in the world, where the greatest use of cactus for forage or fodder occurs in Tunisia: 600,000 ha, Algeria: 150,000 ha, Mexico: 230,000 ha (Nefzaoui and Ben Salem, 2006), South Africa: 525,000 ha and Ethiopia: 355,000 ha (Reveles-Hernández et al., 2010), Brazil: > 600,000 ha (Torres Sales 2010) and Southern Morocco regions: 90,000 ha (Anegay and Boutoba, 2010). In Argentina, there is information about areas cultivated with *Opuntia* only where it is cultivated for fruit production: 2,000 ha in 2003 (Ochoa, 2006).

Opuntia species have the ability to withstand prolonged drought, high temperatures, as well as wind and water erosion. This ability, plus a range of economic uses, makes them ideal for agricultural development in areas affected by the world’s two biggest environmental problems: desertification and climate change (Nefzaoui and El Mourid, 2007).

According to quality standards for legume, grass, and legume-grass mixed hays (Taylor, 1995), the conditions of a quality Prime forage are CP >19 %, ADF <31 %, NDF <40 % and

dry matter digestibility (DMD) 65 %. According to this, all the *Opuntia* forage studied have high DDM, appropriate ADF and NDF contents, but a low content of CP.

Cacti are fairly rich in energy, also rich in minerals, in beta-carotene and water, but poor in fiber and in nitrogen (Le Houérou, 1994).

This review aimed to identify current literature related to *Opuntia* spp. as forage and its validation through experiences with domestic and other animals.

METHODS

The literature review was performed using the Scopus database. This system was chosen because it is considered the largest abstract and citation database of peer-reviewed literature: scientific journals, books and conference proceedings, delivering a comprehensive overview of the world's research output in the fields of science, technology, medicine, social sciences, arts and humanities (http://www.elsevier.com/online-tools/scopus). Scopus presents the results from four different sources: journals with experts' committee; web via Scirus, a specific search engine for scientific publications and web content of scientific pages www.info.scirus.com; patents - results or key patent offices via Scirus and selected sources – showing personalized results of Scirus institutional repositories and collections on specific themes.

The analyzed information comes from the search held on October 3, 2014 using the following strategy: Article title, Abstract, Keywords (TITLE-ABS-KEY(cactus OR opuntia)) AND ((forage OR fodder OR feed)) AND (animal nutrition) and including life, health, physical, social and humanities sciences.

RESULTS

The literature search yielded the following results: with the key words "cactus" OR "opuntia": there were 5,723 documents shown; using the key words "forage" OR "fodder" OR "feed": it resulted in 619 documents and under "animal nutrition": 214 documents were found. The last documents were assigned as Result 1 (R1).

Subsequently, the 214 documents were analyzed individually and 98 of them were selected, (Annex I) all of which involved the experiences with animals both in housing conditions and in extensive grazing, assigned as Result 2 (R2). The titles of the manuscripts in Annex I are reported in English.

In order to compare and understand the significance of the number of citations found for "cactus" OR "opuntia", references for other species found in arid and semiarid areas are presented (Table 1), using the same search strategy.

Table 1. Number of citations for *Opuntia* or cactus and other arid zone native species.

Specie	Total	Forage OR Fodder OR Feed	Animal Nutrition
Cactus OR *Opuntia*	5,723	619	214
Agave	1,676	110	42
Atriplex	1,507	424	134
Prosopis	2,685	462	129

Year

For R1, the first work on the subject of the cactus was published by Field (1851), and it was not until the 70s when papers in which the mention to the use of cactus as fodder and related possible use by animals began to be published (Downs and Houston, 1976, Hoffmann, 1979, Alkamper, 1984, Barrientos Perez, 1984, Benyounes, 1984; Brutsch, 1984, Matter, 1984, Reimers, 1984). In 1994, the first paper involving animals in the assessment of cactus as fodder was published (Ben Salem et al., 1994). The number of publications per year for the results R1 and R2 is presented in Table 2.

For R1, there is a growing trend in publishing documents observed between 2002 and 2013, whereas for R2, the publications increased in 2002, 2007, 2009, 2010 and 2013, rather than in other years.

Document type

There were 184 articles, 15 reviews, 8 conference papers, 4 book chapters and 3 symposia for R1; in R2, there were 93 articles, 2 reviews and 3 conference papers found.

Source title

Table 3 shows the number of articles in the journals that published more papers related to the search strategy and SCImago Journal Rank (SJR) and normalized Source Impact (SNIP).

Affiliation

In R1, six institutions contributed with 27.8% of the publications (Universidade Federal Rural de Pernambuco 9.7%, Institut National de la Recherche Agronomique de Tunisie 8.1%, Universidade Federal da Paraíba 3,2%, Universidad Autónoma de Nuevo León 3.0%, Universidad Autónoma de San Luis Potosí 1.9% and Colegio de Postgraduados 1.9%), whereas for R2, three institutions contributed with 43.3% of the publications (Universidade Federal Rural de Pernambuco 26.5%, Institut National de la Recherche Agronomique de Tunisie 14.3, and Universidade Federal de Viçosa 3.1%).

Table 2. Number of publications per year for the results R1 and R2.

Publication year	Quantity of papers	
	R1	R2
2014	10	2
2013	24	10
2012	21	8
2011	13	2
2010	18	10
2009	27	12
2008	12	6
2007	14	10
2006	15	9
2005	12	8
2004	8	4
2003	9	2
2002	14	10
2001	5	-
2000	2	1
1999	-	-
1998	2	1
1997	2	1
1996	2	1
1995	-	-
1994	1	1
1984	3	
Total	214	98

Table 3. Journals that included the largest number of manuscripts related to the search strategy.

Journal	Papers R1 (n=214)	Papers R2 (n=98)	SJR (2013)	SNIP (2013)
Revista Brasileira de Zootecnia	26	25	0.37	0.643
Acta Horticulturae	18	7	0.193	0.243
Small Ruminant Research	17	11	0.654	1.133
Animal Feed Science and Technology	10	7	1.104	1.321
Journal of the Professional Association for Cactus Development	7	1	0.124	0.465
Livestock Research for Rural Development	7	5	0.26	0.495
Journal of Applied Animal Research	6	2	0.27	0.507
Journal of Arid Environments	5	2	1.004	1.365
Revista Brasileira De Saúde E Produção Animal	5	5	0.152	0.238
Tropical Animal Health and Production	5	4	0.522	0.974
Rangeland Ecology and Management	4	3	1.121	1.276
Others R1	104		0.749	0.928
Others R2		26	0.647	0.955

SJR (2013)= SCImago. Journal Rank reflects prestige of sources: value of weighted citations per document.
SNIP (2013)= Source Normalized Impact per paper: corrects for differences in the frequency of citation.
The values of SJR and SNIP for others R1 and R2 represent the mean values of the 104 and 25 publications, respectively.

Country

Five countries contributed with 69.2% of the publications for R1 (Brazil 21.1%, Tunisia 18.0%, Mexico 14.1%, United States 11.7% and Ethiopia 4.3%), whereas for R2, the same countries contributed with 89.8% of the documents (Brazil 43.9%, Tunisia 22.4%, Mexico 9.2%, Ethiopia 8.2% and the United States 6.1%. For R2, the workplace of the first author was used to determine the country, based on the participation and responsibility of the first author in the preparation of the manuscript (Di Consa 2010; Mary Mutt, 2013).

Source type and Language

There were 209 articles, 1 symposium and 4 books in R1 and 94 articles, 2 reviews and 2 conference papers were included in R2. Documents included by Scopus as Book Series in respect to Acta Horticulturae were changed to articles in R1. Most of the publications (79.8%) in R1 were published in English and 17.1% in Portuguese. In R2 67.3% were in English and 29.6% in Portuguese.

Animals used in the experiences of the documents included in R2

Sheep (46), cattle (21) and goats (18) were the animal species most used in the experiences included in R2; other species used in R2 were: Cattle and sheep: 1; Goat and sheep: 1; Praire dog, goat and sheep: 1, Sheep and dromedary: 1, Dromedary: 2, Rabbit: 2, Deer: 1, Elephant: 1, Greater Kudu: 1, Rat: 1 and Rhea: 1. From the 98 experiences with animals, 83 were carried out indoors and 15 in grazing conditions.

Particular analysis of the publications in the Journal of the Professional Association for Cactus Development according to Scopus

The Journal of the Professional Association for Cactus Development (JPACD) was chosen because it includes papers mostly related to cacti. The 15 volumes (1996-2013) of JPACD contain a total of 155 documents (http://jpacd.org/?modulo=JS); but only one article includes a validated animal experience. Of the 155 documents Scopus relieves only 80. Volumes 1996, 1997, 1998, and 2001 were not included. Also Volume 2012 was not mentioned, although 3 (Lema-Rumińska and Niedojadło, 2012; Montiel et al. 2012; Rothman et al. 2012) from 5 documents include cactus or opuntia as keywords. One document from 2012 was included in 2011 (Rothman et al., 2012). In 2010 Scopus included 6 of 14 published documents, and from the remaining 8 there were 4 (Calvo–Arriaga et al. 2010; Cruz–Hernández and Paredes–López, 2010; Romo–Campos et al. 2010; Tiznado–Hernández et al. 2010) that have a keyword and are not covered by Scopus. In 2009 there was a document (El–Samahy et al. 2009) with keyword that was not included as well. The JPADC (Volume 10, 2008) had 14 papers, although Scopus relieved 8. Only 2 (Corrales-Garcia and Canche-Canche, 2008; Loza Cornejo et al., 2008) of the 6 manuscripts not included do not have any of the keywords used in the search. In 2003 there is one missing document with keywords (Mertens, 2003).

CONCLUSIONS

Even if Scopus shows some tendencies, it is detected that omitted some documents in the review. There are few contributions regarding experiences that include cactus as part of the animal diets. Three institutions contributed with more than 40% of publications that involving animals. There is an important contribution of publications on *Opuntia* by Brazil, Ethiopia, Mexico, Tunisia and United States.

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ANNEX I

2014

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