Seasonal trends of chlorophylls a and b and carotenoids$_{(x + c)}$ in native trees and shrubs, northeastern Mexico.

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Introduction.

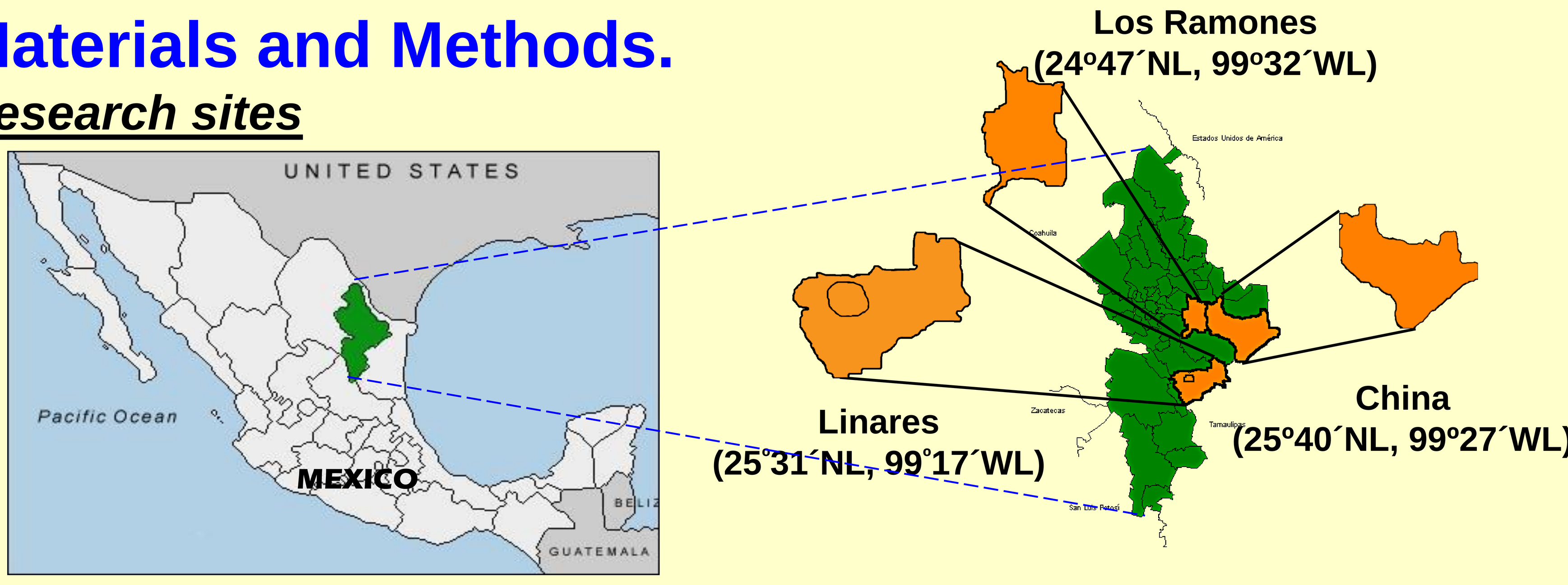
Chlorophylls and carotenoids are essential pigments of higher plant assimilatory tissues and responsible for variations of color from dark-green to yellow. Moreover, they play important roles in photosynthesis capturing light energy which is converted into chemical energy (Bauernfeind, 1981; Young and Britton, 1993). Through the process of photosynthesis, chlorophylls are capable of channeling the radiant energy of sunlight into the chemical energy of organic carbon compounds in the cell (Nichiporovich, 1974). Carotenoids are a class of natural fat-soluble pigments found mainly in plants, algae, and photosynthetic bacteria, where they also play a critical role in the photosynthetic process. Native shrubs and trees that grow in the semiarid regions of northeastern Mexico are important feed resources for range ruminants and white-tiled deer.

Objetive.

To quantify and compare, seasonally during two consecutive years, the content of photosynthetic pigments in trees and shrubs that grow under a similar climatic pattern in northeastern Mexico.

Materials and Methods.

Research sites



Pigment Extraction Protocol and Plant Material

The chlorophylls **a** and **b** and carotenoids$_{(x + c)}$ were extracted in 80% (v/v) aqueous acetone. Pigment measurements were quantified spectrophotometrically using a Perkin-Elmer Spectrophotometer. Absorbances of chlorophylls **a** and **b** and carotenoids$_{(x + c)}$ extracts were determined at wavelengths of 663, 645 and 470 nm, respectively. Concentrations (mg g^{-1} fw) of pigments were calculated by equations of Lichtenthaler and Wellburn (1983). Plant species such as *Acacia rigidula* Benth. (Fabaceae, shrub), *Bumelia celastrina* H. B. K. (Sapotaceae; tree), *Castela texana* Torr & Gray (Verbenaceae; shrub), *Celtis pallida* Torr. (Ulmaceae; shrub), *Croton cortesianus* Kunt. (Euphorbiaceae; shrub), *Forestiera angustifolia* Torr. (Oleaceae; tree), *Karwinskia humboldtiana* Roem et Schult. (Rhamnaceae; shrub), *Lantana macropoda* Torr., (Simaroubaceae; shrub), *Leucophyllum frutescens* Berl. (Scrophulariaceae; shrub), *Prosopis laevigata* (Willd) M.C. Johnst. (Fabaceae; tree) and *Zanthoxylum fagara* L. (Rutaceae; tree), that are the most representative of the native vegetation of the northeastern Mexico were selected for pigment analysis. Foliar plant tissue were sampled seasonally during two consecutive years: in summer, 2004 (August 28); fall, 2004 (November 28); winter, 2005 (February 28); spring, 2005 (May 28); summer, 2005 (August 28); fall, 2005 (November 28); winter, 2006 (February 28) and spring, 2006 (May 28).

Table 1. Seasonal mean air temperatures (ºC) and rainfall (mm) at research sites in northeastern Mexico.

	Site					
	Los Ramones		China		Linares	
Season	Temperature	Rainfall	Temperature	Rainfall	Temperature	Rainfall
Summer 2004	22.8	294	23.6	457	23.6	447
Fall 2004	17.7	96	19.4	31	22.1	95
Winter 2005	10.1	98	11.3	74	13.4	133
Spring 2005	16.5	96	18.2	140	20.5	94
Summer 2005	23.1	322	24.5	486	23.4	465
Fall 2005	17.2	194	19.5	101	19.0	316
Winter 2006	8.7	4	11.5	14	9.7	9
Spring 2006	18.8	158	19.9	150	19.6	79

Table 2. Calculated mean square values from the statistical analysis corresponding to data collected between summer 2004 and spring 2006 of eleven plant species at northeastern Mexico.

Sites	Sources of variation	Chlorophyll **a** MS	*F value*	Sig	Chlorophyll **b** MS	*F value*	Sig	Carotenoids MS	*F value*	Sig
Los Ramones	Years	0.3	25	***	0.2	152	***	0.02	21	***
	Seasons	0.1	6	***	0.1	63	***	0.1	96	***
	Plant Species	0.1	11	***	0.01	5	***	0.03	34	***
	Y*S	0.3	28	***	0.1	35	***	0.02	20	***
	Y*PS	0.04	4	***	0.01	5	***	0.001	1	**
	S*PS	0.1	7	***	0.01	8	***	0.01	5	***
	Y*S*PS	0.1	8	***	0.01	4	***	0.01	5	***
	Error	0.01			0.002			0.001		
China	Years	0.2	15	***	0.2	53	***	0.01	9	***
	Seasons	0.03	3	*	0.2	61	***	0.1	79	***
	Plant Species	0.4	33	***	0.1	14	***	0.1	108	***
	Y*S	0.1	11	***	0.02	8	***	0.01	22	***
	Y*PS	0.1	10	***	0.01	5	***	0.01	8	ns
	S*PS	0.1	8	***	0.01	3	***	0.01	11	***
	Y*S*PS	0.1	11	***	0.01	4	***	0.01	6	***
	Error	0.01			0.003			0.001		
Linares	Year	0.6	38	***	0.02	6	**	0.04	31	***
	Season	0.1	6	***	0.2	51	***	0.1	70	***
	Plant Species	0.2	13	***	0.1	18	***	0.04	36	***
	Y*S	1.0	47	***	0.1	44	***	0.04	32	***
	Y*PS	0.1	9	***	0.01	4	***	0.01	5	***
	S*PS	0.1	9	***	0.02	7	***	0.01	6	***
	Y*S*PS	0.1	6	***	0.02	7	***	0.01	4	***
	Error	0.01			0.003			0.001		

Results.

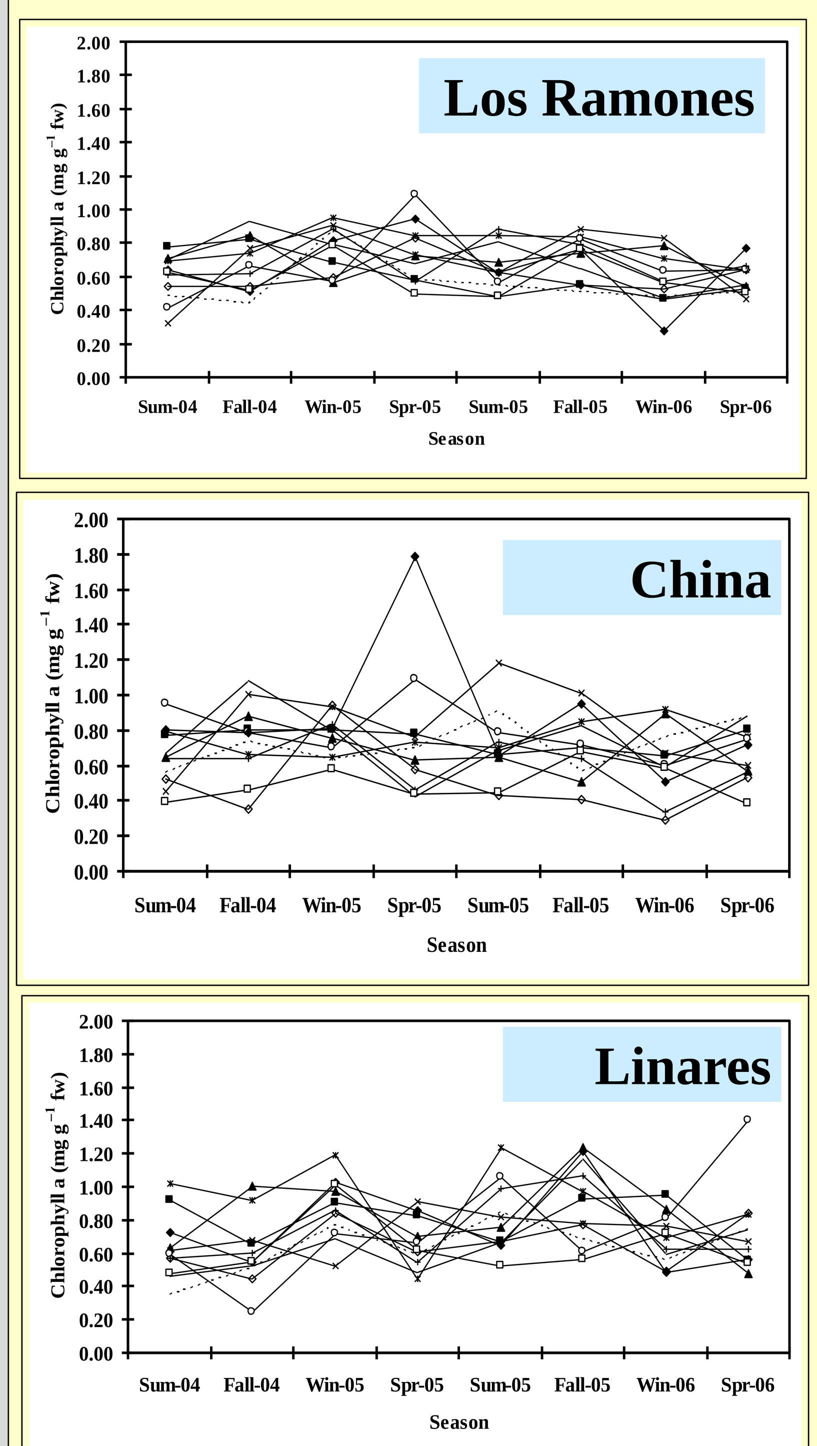


Figure 1. Seasonal contents of chlorophyll **a** at Los Ramones, China, and Linares sites in eleven native trees and shrubs. Sum-04 = Summer 2004; Win-05 = Winter 2005; Spr-05 = Spring 2005; Sum-05 = Summer 2005; Win-06= Winter 2006; Spr-06 = Spring 2006. *C. cortesianus* (◊); *L. frutescens* (■); *K. humboldtiana* (▲); *A. rigidula* (x); *B. celastrina* (*); *P. laevigata* (○); *C. pallida* (+); *Z. fagara* (–); *F. angustifolia* (-); *L. macropoda* (♦); *C. texana* (□).

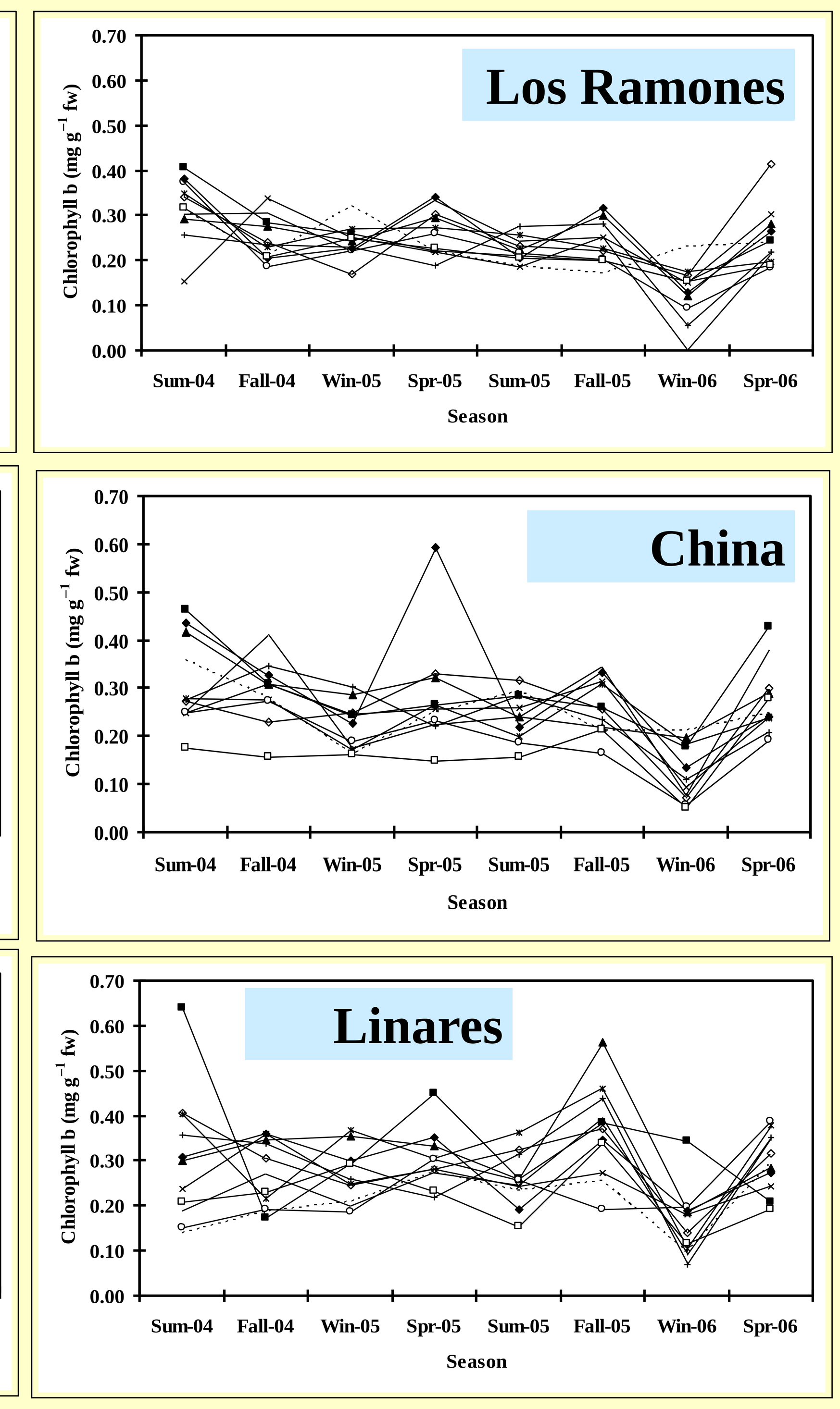


Figure 2. Seasonal contents of chlorophyll **b** at Los Ramones, China, and Linares sites in eleven native trees and shrubs. Sum-04 = Summer 2004; Win-05 = Winter 2005; Spr-05 = Spring 2005; Sum-05 = Summer 2005; Win-06= Winter 2006; Spr-06 = Spring 2006. *C. cortesianus* (◊); *L. frutescens* (■); *K. humboldtiana* (▲); *A. rigidula* (x); *B. celastrina* (*); *P. laevigata* (○); *C. pallida* (+); *Z. fagara* (–); *F. angustifolia* (-); *L. macropoda* (♦); *C. texana* (□).

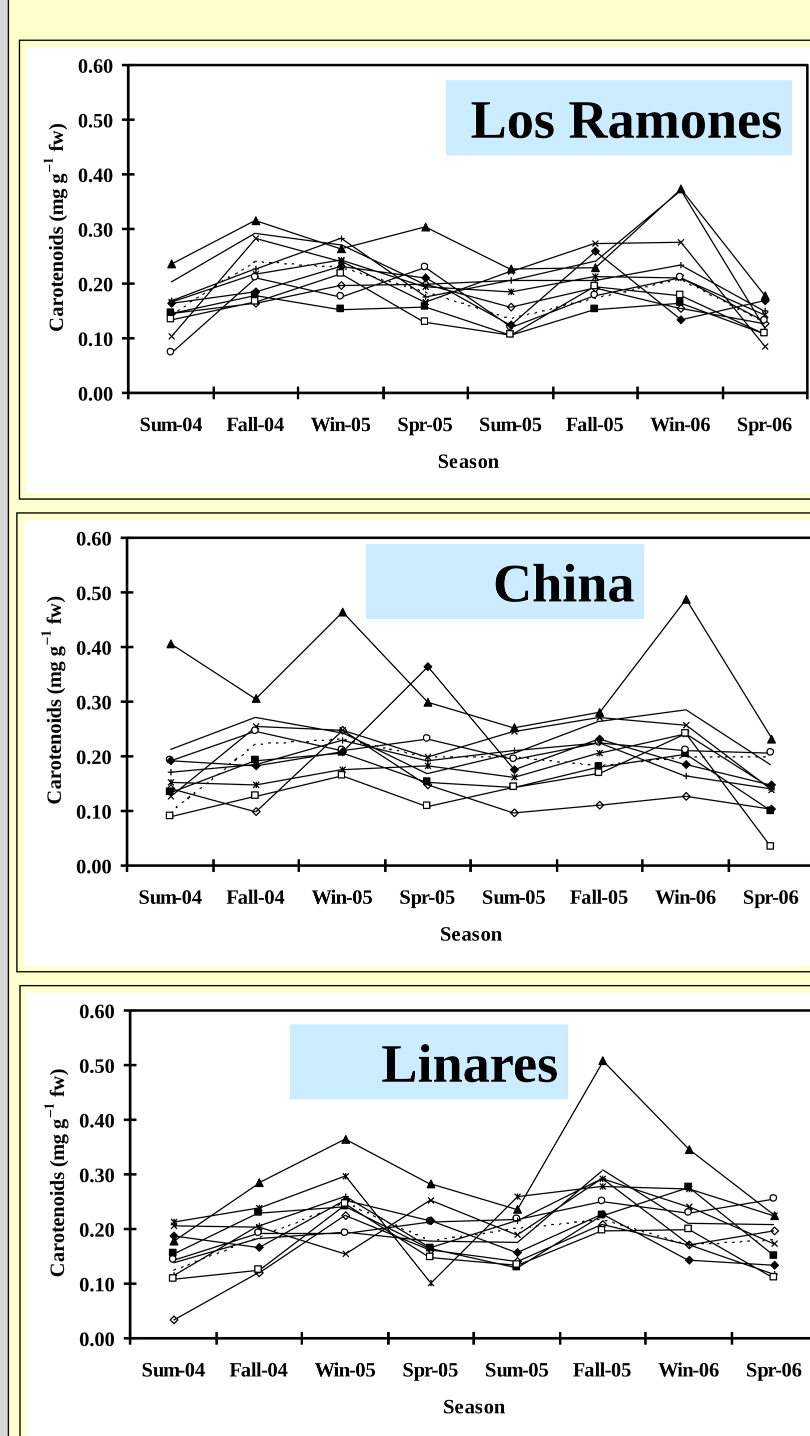


Figure 3. Seasonal contents of carotenoids$_{(x+c)}$ at Los Ramones, China, and Linares, sites in eleven native trees and shrubs. Sum-04 = Summer 2004; Win-05 = Winter 2005; Spr-05 = Spring 2005; Sum-05 = Summer 2005; Win-06= Winter 2006; Spr-06 = Spring 2006. *C. cortesianus* (◊); *L. frutescens* (■); *K. humboldtiana* (▲); *A. rigidula* (x); *B. celastrina* (*); *P. laevigata* (○); *C. pallida* (+); *Z. fagara* (–); *F. angustifolia* (-); *L. macropoda* (♦); *C. texana* (□).

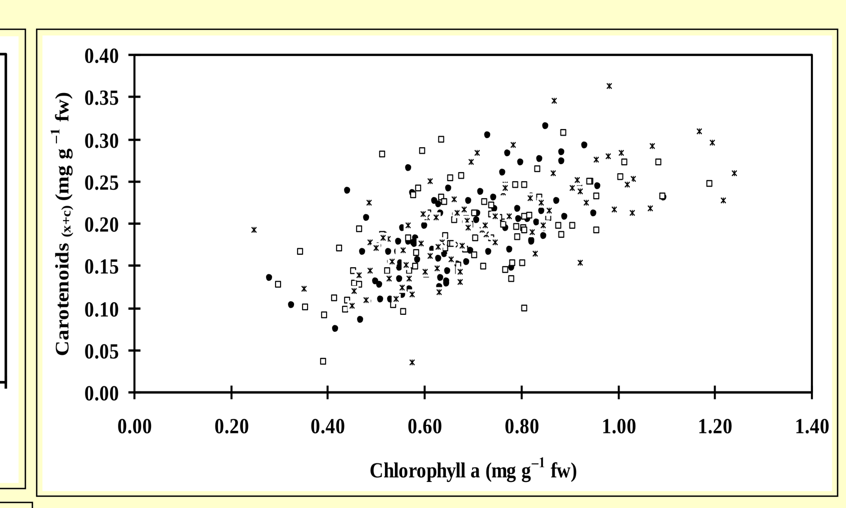
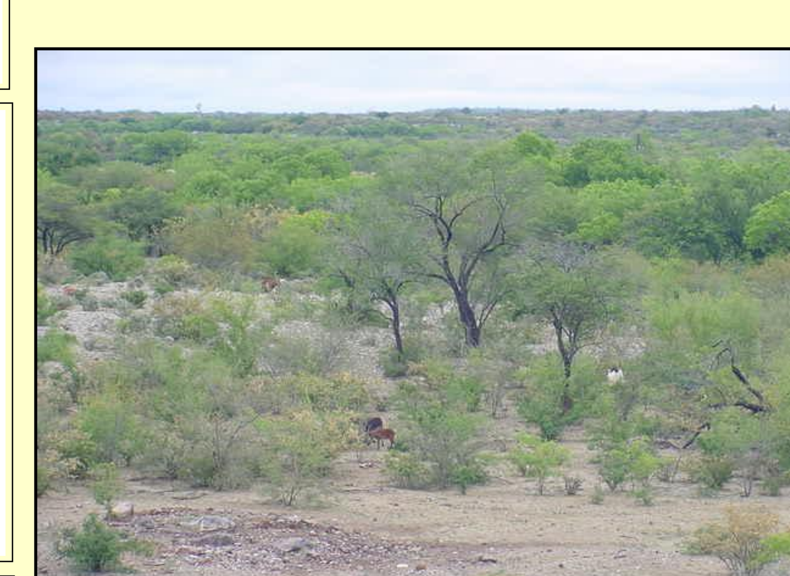


Figure 4. Relationship between leaf carotenoids$_{(x+c)}$ content and chlorophyll **a** for all leaf tissue samples in 11 native trees and shrubs at four sampling seasons and two consecutive years. Plotted data points are means from four independent measurements per plant species per season per year. Los Ramones (•); China (□); Linares (*).



Implications:

Results of the present study suggest that, even though, all plants differed in pigment content and followed a seasonal pattern, during adequate or adverse conditions such as extreme temperatures and water shortages, they still could play important roles in maintaining the productivity of dry rangeland ecosystems. However, studies on leaf tissue at morphological, anatomical, biophysical, biochemical, physiological, and molecular level should be addressed to elucidate the underlying mechanisms employed by these trees and shrubs to adapt to this ecosystem and to deal with prolonged drought periods, high temperatures and high irradiance levels, with the purpose to identify fundamental mechanisms that increase or reduce pigment concentration, and how they are related to photochemical efficiency, photoinhibition and tissue water relations.