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Productive potential, morphometry, nutritional value, and nutrient recycling of wild populations of *Distichlis spicata* (L.) Greene

Potencial productivo, morfometría, valor nutricional y reciclaje de nutrientes de poblaciones silvestres de *Distichlis spicata* (L.) Greene

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ABSTRACT

Halophyte grasses constitute an alternative for animal feeding in semi-desert and arid ecosystems. Thus, the objective of the present study is to evaluate *Distichlis spicata* wild populations in mineral productivity, morphometry, nutritional value, and recycling in two coastal ecosystems in Baja California Sur, Mexico. The data associated with the study were analyzed using an unbalanced two-factor experimental design: Factor A represented by the Pacific Ocean and the Gulf of California coastlines with two levels; Factor B represented by the natural condition in which *D. Spicata* populations are located, either alone or associated with other plant species. Three repetitions were considered for each level in each study factor. The variables evaluated were green, dry, and dead matter, Na^{+1}, Fe^{+2}, Mn^{+2}, Zn^{+2}, Ca^{+2}, Mg^{+2}, $K^{+1,}$ and Cu^{+1} contents in plant tissue, chemical composition (crude protein, acid, and neutral detergent fiber, and acid-detergent lignin), cellulose, hemicellulose, nitrogen bound acid-detergent fiber and acid-detergent insoluble ash, and *D. spicata* nutritional value. The texture was determined in the soil. The results showed that *D. spicata* grows and develops on both coasts near wetlands, lagoons, intertidal regions, pools, and tide pools, all at the coastal level, chemical composition and nutritional value resembled by the bromatological and tropical grass patterns. In conclusion, the morphometric and productive characteristics suggest the forage suitability of the species.

KEY WORDS: Halophytes, gramineous, arid zones, coastal vegetation, forage species, nutritive value.

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RESUMEN

Los pastos halófitos constituyen una alternativa para la alimentación animal en ecosistemas semidesérticos y áridos. El objetivo del presente estudio fue evaluar la productividad, morfometría, valor nutricional y reciclaje de minerales de poblaciones silvestres de *Distichlis spicata* en dos ecosistemas costeros en Baja California Sur, México. Los datos asociados al estudio se analizaron mediante un diseño experimental bifactorial no equilibrado, con el factor A representado por los Litorales Costeros con dos niveles, Costa del Océano Pacífico y Costa del Golfo de California y el factor B representado por la condición natural en que se encontraron las poblaciones de *D. spicata*, solo o asociado con otras especies vegetales, considerando tres repeticiones para cada nivel en cada factor de estudio. Las variables evaluadas fueron materia verde, seca y muerta, contenido de Na^{+1}, Fe^{+2}, Mn^{+2}, Zn^{+2}, Ca^{+2}, Mg^{+2}, K^{+1} y Cu^{+1} en tejido vegetales, composición química (proteína cruda, fibra detergente ácido, fibra detergente neutro, lignina ácido detergente, celulosa, hemicelulosa, nitrógeno enlazado a la fibra detergente ácido y cenizas insolubles en detergente ácido) y valor nutritivo de *D. spicata*. En el suelo se determinó la textura. Los resultados mostraron que, *D. spicata* en ambos litorales crece y se desarrolla cerca de humedales, lagunas, región intermareal, pozas y charcas de marea, todos a nivel de costa, su composición química y valor nutritivo se asemejó al patrón bromatológico de las gramíneas tropicales. Se concluye que, las características morfométricas y productivas sugieren una aptitud forrajera de la especie.

PALABRAS CLAVE: Halófitas, gramíneas, zonas áridas, vegetación costera, especies forrajeras, valor nutritivo.

Introduction

Marine coastal ecosystems are as old as life (Barrett-Lennard *et al*., 2016), where their fauna and flora species have developed typical morphophysiological adaptations, such as water efficiency and sodium chloride (NaCl) in a vacuole, making use of sodium (Na) as an osmotic potential salinity soil regulator (Negacz *et al*., 2021) and/or adaptations for living. For example, different types of exudates and the presence of specialized glands eliminate surplus NaCl and capture chlorides in calcium oxalate (CaOx) crystal formations or magnesium (Mg) (Barrett-Lennard *et al*., 2016; Zucol *et al*., 2019). The plants related to NaCl are designated as halophyte or halotolerant, referring to both terms at different levels of tolerance or needs of salt. To comply with their life cycles, halophytes may be found in swamps, mangroves, salt marches, and coasts, where soil salinity is very high (35 g kg^{-1} saline water) (Srinivas *et al*., 2018; Garrett *et al*., 2020).

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The most known halophyte and halotolerant species are *Salicornia bigelovii* and *Atriplex canescens.* (Amaranthaceae), *Sporobolus indicus, Spartina alterniflora,* and *Distichlis spicata* (Poaceae). These species are resources of interest in some ecosystem regions predominantly characterized by salinity for phytoremediation, energy, ornamentation, and human consumption, besides receiving good acceptance by some consumers as the Amaranthaceae family (Ventura & Sagi, 2013). The species of the Poaceae family, represented by the *Sporobolus* genus, are distributed in the American continent, and used as forage and as ecosystem restoration (Al-Shorepy *et al*., 2010). The genus *Distichlis* is considered a species with very low forage value, even as weed, in environments with the production capacity for other types from good to very good quality. However, it is an important resource in saline environments (Yensen & Weber, 1985; Bustan *et al*., 2005) and soil erosion reduction (Pensiero *et al*., 2021).

In Australia (Norman *et al*., 2013; Smith *et al*., 2022), Iraq (Salman *et al*., 2013), the United Arab Emirates (UAE, 2006; Al-Shorepy *et al*., 2010), Jordan (Massimi *et al*., 2016), and Argentina (Barbosa *et al*., 2023) marsh and halophyte grasses are species used for feeding ruminant animals, combining edaphic climate limitations and developing sustainable systems contrasting with high salinity, drought and erosion (Norman *et al*., 2021; Bondaruk *et al*., 2022). The alternatives developed for domestic halophyte species for animal feed are a critical route. Among those that stand out are species prospection and evaluation in natural (Barrett-Lennard *et al*., 2016; Norman *et al*., 2021) and controlled (Chen, 2015; Li *et al*., 2018) environments. The development of variant management systems considers grazing (Barbosa *et al*., 2023; Smith *et al*., 2022) with alternatives, such as chemical fertilization (Norman *et al*., 2020) and reduction of oxalate crystal reduction on leaf tissues (Al Daini *et al*., 2013). Nevertheless, despite Mexico having extremely arid, desert, and semi-desert climates has not been considered an alternative where livestock develops.

Baja California Sur (BCS) México shows several climate types. For example, temperate (0.94 %), very hot-dry (63.1 %); very dry and hot (28.5 %), whereas its surface is desert (89.1 %) predominantly arid (97.5 %). These climate types are conditioned by the biogeographic region limited predominantly by a mountainous region of more than 400 km in length from the south (Sierra San Lázaro, La Laguna, and Las Cacachilas) to the north (Guadalupe and San Francisco) and limits with the Pacific Ocean. The regions show their environmental features, such as climate and geology (León de la Luz *et al*., 2018), and important condition limitations for agriculture and livestock development. However, they promote an exclusive floristic abundance (Espejel *et al*., 2017) with productive potential genera to be used in ruminant feed; one that stands out is *Distichlis spicata* grass characterized as non-domesticated halophyte Gramineae that grows and develops in hostile salinity environments with physiological adaptations and morphometric implications (Elzenga *et al*., 2021; Negacz *et al*., 2021).

Distichlis spicata has been described as a fibrous plant of low protein (<10 %) and high mineral (>70 %) contents with a wide agronomical variability determined by salt content in the nutritional solution or soil type where it develops (Escobar-Hernández *et al*., 2005). This species is considered a candidate for animal feed in the conditions of Baja California Sur and the development of feed production systems that allow for improving palatability, chemical composition, and nutritional value. However, the productive and structural response of animal feed should be known in its natural conditions since it is an autochthonous grass that possesses the variation and potential to confront adverse edaphoclimatic conditions. Thus, its evaluation is important to solve the limitations that salinity stress imposes (Zamin & Khattak, 2018), as well as agronomic variability, chemical, and productive composition, starting from salt concentration in cultivation media (Escobar-Hernández *et al*., 2005)

In this context, *D. spicata* is expected to show variability in its morphometric, productive, chemical composition, and nutritional value response within the ecosystemic coastal gradients of Baja California Sur. Therefore, the objective of the present study is to evaluate the productivity, morphometry, nutritional value, and mineral recycling of the wild *D. spicata* (L.) Greene populations in two coastal ecosystems of Baja California Sur, México.

Material and Methods

Study site

The study was performed in the state of Baja California Sur (BCS), México, which occupies the distal portion of the Baja California Peninsula, extending from 22° 52´ to 28° 00´ N latitude and 109° 15´ to 115° 05´ W longitude; BCS limits to the north with the state of Baja California (BC), to the south and west to the Pacific Ocean and the east to the Gulf of California, separating it from the rest of the Mexican territory. The peninsular climate is desert, BW (very hot and dry), with variations in the southern portion that includes type BS (hot and dry). Annual medium temperature oscillates from 22 to 24 °C with annual precipitation from 150 to 250 mm (León de la Luz *et al*., 2015). Soil type is variable, coming from different origins, on which subsequent alluvial deposits have accumulated. In general terms, they correspond to xerol and yermosol types that show high carbonate levels; regosole and litosole derive from yermosole, corresponding to immature soils without well-defined horizons or levels that predominate in flatlands and low hills. In the coastal strips, marine terraces stand out caused of tectonics and constant changes in sea level (León de la Luz *et al*., 2015).

Plant species used

Distichlis spicate is an herbaceous, dioecious, perennial, and rhizomatous plant with multiflower spikelets and leaves conspicuously arranged distinctly; the plant inhabits humid and saline soils (Figure 1) and belongs to the Poaceae family, Chloridoideae subfamily, Cynodonteae tribe, and Monanthochloineae subtribe (Peterson *et al*., 2001). The species is distributed along the coasts and in the interior of the American continent with one of its species recorded in Australia (Beetle, 1943). The criteria on its genus include three or six species up to 12 subspecies and varieties, generating differences between several authors in relation to the classification at the infra-genetic level (López-Soto *et al*., 2009; Echeverría *et al*., 2020).

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Figure 1. *Distichlis spicata* plants growing in intertidal areas of the Pacific coastline in Baja California Sur, Mexico.

Photo by Ledea-Rodríguez, J.L at coordinates N 23º 56´ 27030” W 110º 50´ 52.68”.

Experimental design

Data associated with this study were analyzed by a non-balanced bifactorial experimental design whose factors in study were, Factor A represented by the coastal areas with two levels, the Ocean Pacific and Gulf of California; Factor B represented by *D. spicata* natural populations with four levels: *D. spicata* growing alone, *D. spicata* associated to mangrove (*Rhizophora mangle* spp.), *D. spicata* associated to *Salicornia bigelovii*, and *D. spicata* associated to other vegetations considering three repetitions for each level in each factor.

Sampling procedure

The present study was developed from May to September 2019. Sampling points were distributed along the state of Baja California Sur (BCS), México, including both the Pacific Ocean and the Gulf of California coastlines, approximately 100 ± 60 km among sampling points in function to coastal access to *D. spicata* availability (Figure 2).

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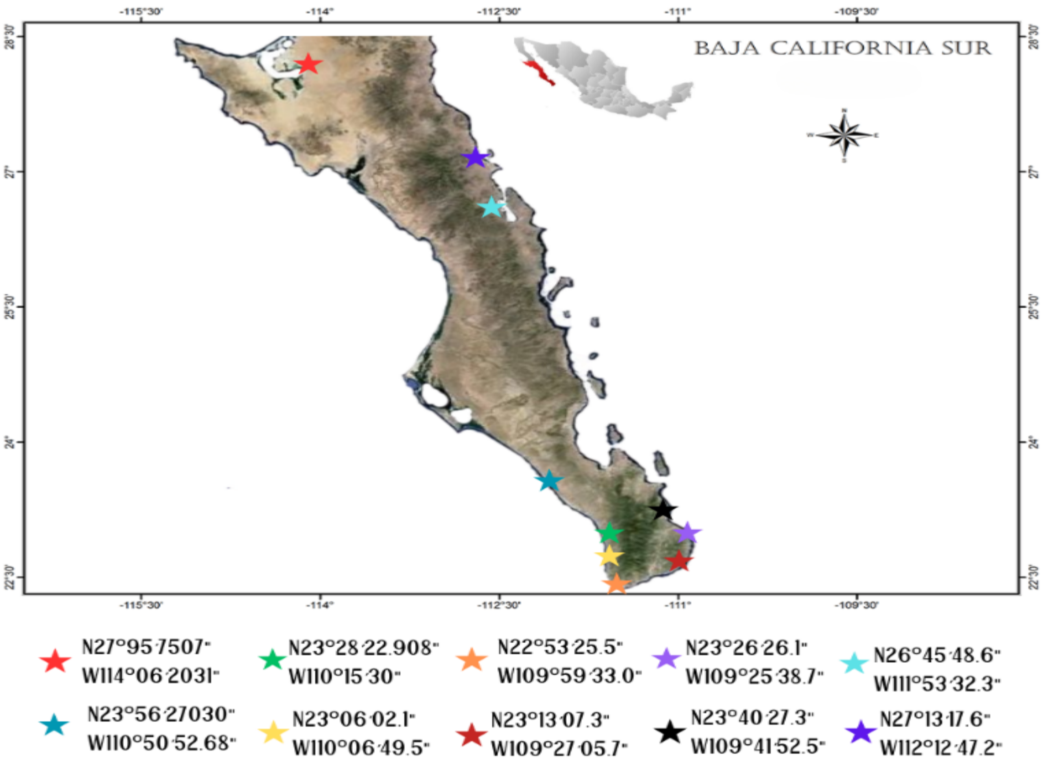

Figure 2. ***Distichlis spicata*** **sampling sites in Baja California Sur, Mexico.**

Own creation through https//canvas.com.

Soil texture

Soil samples were taken at depths from 0 to 50 cm in each sampling site and/or grass growth condition in both coastlines (Pacific Ocean and Gulf of California), collecting approximately 1 kg of soil per sampling site. The samples were transferred to CIBNOR (Centro de Investigaciones Biológicas del Noroeste) Soil Studies Laboratory according to Lewis & McConchie (2012) methodology; soil texture was determined using the laser (LA950, Horiba® Instruments Inc., Irvine, CA, USA) method.

In each sampling condition corresponding to each coastline, *D. spicata* samples were taken in triplicate using a 1-m^2 sampling area made by a wooden quadrant (Figure 3). The plants

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were identified by taxonomic keys facilitated by CIBNOR Anetta Mary Carter Herbarium (HCIB code 003867) and subsequently confirmed by the same herbarium samples.

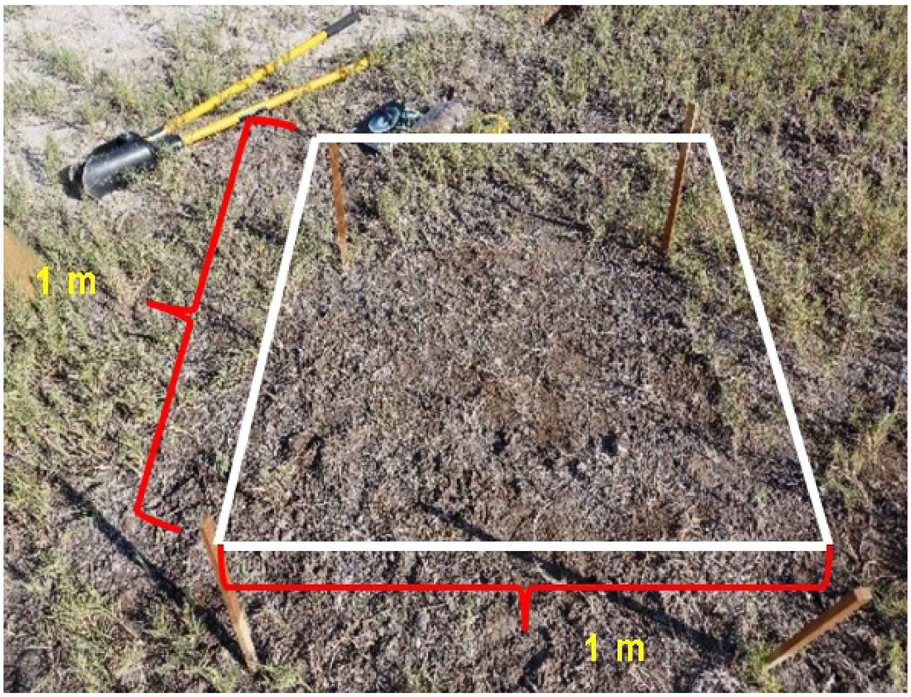

Figure 3. Layout and dimensions of the 1 m^2 frame through which *Distichlis spicata* samples were taken at each sampling point.

Own creation from Microsoft Paint® image editor. Windows® 11.

To estimate green (GM) dry (DRM) and dead (DM) matter yield, ten *D. spicata* plants were selected and weighed in total biomass. Subsequently, within the quadrant, *D. spicata* samples (300 g each one, approximately) were taken, placed in paper bags, and transferred to laboratoy of animal nutrition and morphophysiology at the Autonomous University of Baja California Sur (UABCS) located in La Paz, Baja California Sur, where *D. spicata* proximal composition, mineral, and nutritional value contents were determined.

Morphometric variables

The bags with *D. spicata* determining morphometric values were sent to CIBNOR Plant

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Physiology Laboratory, where the number of green leaves, stem nodes, and thickness were quantified by electronic calibration with digital Vernier screen type 0-150 mm (Leidsany, Britt Technology Inc, American Samoa). Measurements were performed at 5 cm from the stem base upward also measuring total plant length, considered from the stem base up to the last leaf ligule.

Estimation of green (GM), dry (DRM), and dead (DM) matter

Productivity estimation of plant matter collected was performed by separating GM from DM matter. The GM samples were dried in environmental shade and temperature and subsequently dried in a stove (HTP-80® Lumistell, Celaya, Guanajuato, México) at 50 °C until constant weight was obtained. Then, GM value was estimated in DRM by arithmetic relations per hectare (DRM ha^{-1}). The same procedure was applied to DM, considering it for GM estimation and for DRM after the drying process.

Mineral profile, extraction, and nutrient incorporation

The obtained DRM was crushed and pulverized in a grinder (Braun 4-041® KSM-2 Model, Germany); from this material, 100 g were taken for estimating Na^{+1}, Fe^{+2}, Mn^{+2}, Zn^{+2}, Ca^{+2}, Mg^{+2}, K^{+1}, and Cu^{+1}, same which were quantified by spectrophotometry atomic absorption (Shimadzu AA-660®, Shimadzu, Kyoto, JP) previous to digestion with H_2SO_4, HNO_3 and $HClO_4$ (1:10: 4). Then, P was estimated by colorimetric measuring 660 nm in a specific blue color of phosphomolybdate of the same extract. Total N was determined by Kjeldahl digestion, using a mixture of sulfuric and salicylic acids with $CuSO_4$ and K as catalyzers, followed by an estimation of ammonium using Nessler calorimetric method. Soil nutrient extraction was determined by multiplying dry grass weight by the concentration of Ca^{+2}, Mg^{+2}, P^{+3}, K^{+1}, and Na^{+1}, Fe^{+2}, Mn^{+2}, and P^{+3} according to Crespo *et al*. (2000) criteria by the equation:

$$Extracción\ de\ minerales\ (\%) = Peso\ seco\ x\ minerales\ en\ tejidos \quad (1)$$

The incorporation of nutrients was estimated from the mineral concentration of the litter or dead matter (DM), multiplying the percentage of DRM by the mineral concentration (%), through the same equation previously described. The relationship between mineral extraction/ incorporation was estimated by the set of extraction and incorporation values, respectively.

Samples for estimating chemical composition and nutritional value

The pulverized plant material was divided into 300-g samples and stored in yellowish-brown bottles duly identified and transferred to the Animal Nutrition and Morpho-physiology Laboratory of the Universidad Autónoma de Baja California Sur (UABCS), located at 24º 05´ 58” N L and -110º 18´ 45” W L in the city of La Paz, Baja California Sur.

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Distichlis spicata fibrous, nitrogenous, and nutritional fraction values

Gross protein (GP) and DRM were determined according to the Association of Official Agricultural Chemists (AOAC, 2016). The acid (ADF), neutral (NDF), and lignin (LDF) detergent fiber, cellulose, and hemicellulose were determined by Goering & Van Soest (1970) technique. Nitrogen linked to ADF (N-ADF) and NDF (N-NDF) was determined according to that indicated by Van Soest *et al*. (1991), and acid-insoluble ash (AIA) in detergent was determined by muffle furnace at 500 ºC for 24 hours.

Dry matter (DMD) digestibility % was calculated with the following equation:

$$DMD 70.48 - 0.4399\ x\ NDF \qquad \textbf{(2)}$$

Organic matter digestibility (OMD %) was calculated by the equation:

$$OMD = (1.013\ x\ DMD) + (0.258 x prot) - (3.89 x 10^{-3}) x\ prot\ x\ DMD) \qquad \textbf{(3)}$$

Metabolizable Energy (ME, MJ kg DRM^{-1}) was estimated with the following equation:

$$ME\ (MJ\ kg\ DRM^{-1}) = \frac{37.28 x OMD\ (\%) - 148.9}{1000} \qquad \textbf{(4)}$$

Net Lactation Energy (NLE, Mj kg DRM^{-1}) was calculated by the equation:

$$NLE = (26.28\ x\ OMD\ (\%) - 359) \qquad \textbf{(5)}$$

Fattening Net Energy (FNE, MJ kg MS^{-1}) was calculated by the equation proposed by Cáceres & González-García (2000):

$$FNE = (32.52\ x\ DMO(\%) - 793) \qquad \textbf{(6)}$$

Statistical analyses

Data analyses were performed in function of the randomized bifactorial experimental design previously described. The analyses were performed using Statistica software version 12.0; in all cases, normal distribution of data was considered by Kolmogorov & Smirnov (Massey, 1951) test as well as homoscedasticity test following Bartlett (1937) criteria. The coastline effects and grass condition were shown to be efficient as to morphometry, productivity, chemical composition, and nutritional value, as well as nutrient recycling defined when the multivariate analysis was used through the principal component analysis (PCA). The supposed correlations were proven by Kaiser-Meyer-Olkin (KMO) (Kaiser, 1974) and by Bartlett's sphericity test (Bartlett, 1937). The factors were extracted by a correlation matrix based on autovalue and the Varimax method normalized with Kaiser and used for database rotation (Torres *et al*., 1993).

Results and Discussion

Distichlis spicata localization, soil texture and growth conditions in coastal ecosystems in Baja California Sur, México

The results in the present study showed that *D. spicata* grows and develops in both coastlines (Table 1) close to wetlands, lagoons, intertidal regions, puddles, and tidal pools, all of them at coastal level and within the reach of relative residual ocean humidity. This situation is related to the spatial distribution pattern for halophytes that tend to link their location within a humid-saline gradient (Vogt, 2015; DeFalco *et al*., 2017; Karberg *et al*., 2018; Santelmann *et al*., 2019). A similar response was reported in a floristic composition study of coastal grasses or dunes in Peru, where *D. spicata* was the most representative and located in extensive areas with humidity retention properties, high salt content, and organic material (12 %) with plant coverage from 70 to 80 % (Montesinos, 2012). In another study on floristic composition in wetland plant communities, *D. spicata* (Herbario HCIB-003867) presence was identified jointly with other halophyte grass species and genera; canopy height, coverage area, and shoot production in salt grass varied seasonally and between years, conditioned by anthropic activity, generating its disappearance in one year within the period of study, same which happened with some wetland plant community components (Meixler *et al.*, 2018).

Furthermore, in the edaphoclimatic gradient where *D. spicata* is found alone, combined, or associated with coastal grasses, its plant cover in free life hardly goes beyond 30 %. However, due to its adaptive characteristic, it is considered a particularly valuable resource in desert or semidesert ecosystems, despite its low biomass production potential in its natural state (Pensiero *et al*., 2021).

With respect to growth conditions, the present study distinguished the predominant growth only for *D. spicata* although it was also found associated with other grasses called dune vegetation. This last growth condition prevails in the Pacific Ocean coastline (POCL). The species associated with *D. spicata* are *Salicornia spp.* and *Rhizophora mangle spp.* and are found growing next to *Maytenus phyllanthoides* Benth in Los Cabos, BCS. In the site called "playa río abajo" (downstream river) Rancho La Tinaja, *D. spicata* was observed growing associated with *Phaseolus filiformis* and *Ipomoea pres-caprae* (L.) R. Brown, both sites are in POCL (Table 1). With respect to a study performed in Peru, *D. spicata* was found associated with other grasses; among those that stand out are *Atriplex semyriophylla*, *Suaeda foliosa,* and other introduced species in the region ecosystems, such as *Chenopodium petiolare*, *Tarasa operculata*, *Lemonium bellidifolium* and *Atriplex semibaccata*. The grasses to which *D. spicata* was also found are considered predominant vegetation in coastal dunes, which are established in soils where they develop their biological cycle (Espejel *et al*., 2017) and suggest that soil jointly provides nutrients with the respective humid-saline gradient.

Among the population relationships that affect halophyte grass distribution and permanence, those found are plant species, geographic region, climate period, and soil type, adding climate seasonal variations. For example, the principal condition for halophyte grass distribution (Hasnain *et al*., 2023) besides the occurrence of salt marshes supplies the necessary humidity for growth, development, and distribution (Howard *et al*., 2020). Likewise, competence, nutrient availability, and salinity have a determinant role (Valiela *et al*., 2023), and consequently elevation.

The climate and edaphic characteristics of the Baja California peninsula distinguish peninsular eco-regions, of which Baja California Sur has seven of 14 pointed out the region (León de la Luz *et al*., 2015). These characteristics differ according to the climate and rainfall regime. This determinant aspect in the physical environment influences species predominance or displacement of some coastal ecosystems. In this sense, Rasser *et al*. (2013) highlighted the importance of abiotic factors when they evaluated different species distribution in microtidal deltaic wetland conditions close to Corpus Christi on the southwestern coast of Texas, U.S.A., insisting on not ignoring these factors when estimating growth and distribution of coastal grasses.

In the present study, *Salicornia* spp. and *R. mangle* spp. displacement was evident in the Gulf of California coastline (GCCL), considered by the absence of a high surge that allowed access from the sea to the coastlines. In contrast, the POCL surge is frequent and high, besides the differences in relative humidity value and environmental temperature mainly by a micro-climate influence that conditions differences between the coastlines in the same Peninsula (León de la Luz *et al*., 2015).

With respect to soil texture (Table 1), it differs within the own coastlines and between them, which agrees with greater variability in sampling sites where *D. spicata* was found associated with other halophyte grasses. In sampling site soils, sand content was predominant. Soil texture and possible conditions where *D. spicata* was found are related to the regionalization of the Baja California peninsula described by León de la Luz *et al*. (2015). These areas include several well-defined biogeographic regions, the Sonoran Desert and Los Cabos, each one with their environmental features, where geography and climate have an outstanding relationship. *D. spicata* is a plant limited in nitrogen and when it is present in soil, the plant uses it for aerial biomass development and dominance on other species (Lymbery *et al*., 2013; Hill *et al*., 2018). *D. spicata* consumes nitrogen (in its assimilable forms as nitrate (NO_3^-) or ammonia (NH_4^+) rapidly and efficiently captures them in arid conditions through reservoirs present in the organic material contained in DM (James & Richards, 2005). In plant decomposition, *D. spicata* conserves from 60 to 70 % of its organic content through detrital particles (Escobar-Hernández *et al*., 2005). In this manner, the plant equilibrates between extracting and incorporating the mineral needs when it grows in arid environments. Only in climate gradient conditions – as in the case of the Gulf of California and Pacific Ocean coastlines in Baja California Sur – growth conditions (accompanying flora) not limited to coastal grasses or dune vegetation may alter the nutrient need response of this halophyte Gramineae.

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Table 1. Sampling sites with their names, geographical location, and soil texture on both the Pacific Ocean and Gulf of California coastlines in Baja California Sur where *Distichlis spicata* grass grows naturally.

Coastlines	Collection sites	Geographical location	Soil texture (%)			*Distichlis spicata concitions*			
			S	L	CL	Ds.S	Ds.AS	Ds.ARm	Ds.A.Ev
Pacific Ocean	Pozo de Fernandito	N 23°28´22.908”-W 110°15´30	100			x	-	-	-
	Conquista Agraria	N 23°56´27.030”-W 110°50´52.68”	100			-	-	x	-
	Guerrero Negro	N 27°95´7507”-W 114°06´2031”	96	1.75	1.75	-	-	x	x
	Los Cabos	N 22°53´25.5”-W 109°59´33.0”	100			x	-	-	x
	Rancho La Tinaja	N 23° 06´02.1”-W 110° 06´49.5”	92.08	7.80	0.12	x	-	-	x
	Playa Santispac	N 26°45´48.6”-W 111°53´32.3”	100			x	-	x	-
Gulf of California	San Lucas. Santa Rosalía	N 27°13´17.6”-W 112°12´47.2”	77.36	22.5	0.13	x	-	-	-
	Los Barriles	N 23°40´27.3”-W 109°41´52.5”	100			x	-	-	-
	El Cordoncito	N 23°13´07.3”-W 109°27´05.7”	100			x	-	-	-
	Boca del Álamo	N 23°54´32.0”-W 109V49´21.6”	100			-	-	-	x
	El Cardonal	N 23°50´40.7”-W 109°44´44.5”	100			x	-	-	-
	Punta Arena	N 24°03´56.8”-W 109°49´59.3”	100			x	-	-	-
	Viña Ensueños	N 23°59´07.1”-W 119°50´08.9	100			x	-	-	-
	La Ventana	N 24°12´40.1”-W 109°59´08.0”	94.57	5.23	0.2	-	-	-	x
	El Saltito	N 24°14´08.9”-W 110° 08´16.4”	100			-	-	-	x
	Playa Balandra	N 24°19´18.8”-W 110°19´31.8”	100			x	-	-	-
	El Tecolote	N 24°20.1´12.3”-W 110°18.4´15.7”	100			x	-	-	-
	El Comitán	N 24°06´33.2”-W 110°25´02.4”	100			x	-	-	-
	El Mogote	N 24°10´27.1”-W 110°25´08.7”	100			x	-	-	-

S= sand; L= silt; CL= clay. Ds.S= *Distichlis spicata* species growing alone; Ds.AS= *D. spicata* associated to *Salicornia* spp.; Ds.ARm= *D. spicata* associated with *Rhizophora mangle* spp.; Ds.A.Ev= *D. spicata* associated to other grass species.

Morphometric, productivity, and animal load capacity variables

The *D. spicata* variability study showed significant differences in some morphometric, productive, and capacity characteristics to sustain animal load in the function of the nesting grass conditions in both coastlines (Table 2). In this sense, *D. spicata* showed the greatest plant height and number of nods in POCL when found associated with *Rhizophora mangle* spp., which is related to the presence of secondary molecules (tannins). Additionally, NH_4^+ and P^{+3} found in senescent material of *R. mangle* leaves (Zhang & Laanbroek, 2020) promote *D. spicata* growth and development which in turn delay the decomposition of dead leaves (Laanbroek *et al*., 2018). This condition may have intervened to substantially retain it in greater amount with respect to the rest of the POCL grass conditions and contribute to greater average values of the morphometric variables evaluated in the present study associated with *R. mangle* with respect to other forms in POCL (only and associated) and GCCL (only and associated to *Salicornia* spp).

The green leaves number and stem morphometry (width and number) showed similar values in the different growth conditions for *D. spicata* on both coastlines. On the other hand, DRM yield showed an increment tendency in each coastline condition with values ranging from 0.50 to 1.15 t DRM ha^{-1}, but DM did not show significant differences expressing ranges from 0.10 to 0.27 t DM ha^{-1}. The DM contributions should be considered because they are part of the plant ecosystemic service and determine the presence of microbial communities with transversal effect on the nutrient cycle (Ferreira *et al*., 2023).

The rangeland showed values from 4 to 5 ha AU $year^{-1}$ in POCL and 6 to 9 ha AU $year^{-1}$ in GCCL. The differences in grass conditions on each coastline were not significant. However, it is important to point out that in GCCL the grass condition alone and associated with other grasses showed a higher rangeland coefficient than 5 ha AU $year^{-1}$ (Table 2); similar values were reported by Barbosa *et al*. (2023) when forage production was estimated in saline wetlands with an animal load of 8.6 reproductive cows/ha. On the other hand, Pensiero *et al*. (2021) suggested the use of *D. spicata* as forage for goat feed and in a lesser measure for horses, considering from 8 to 24 % as cattle diet component in wetlands (Brizuela *et al*., 1990).

The redundant values in the forage potential of *D. spicata* to tolerate an elevated animal load agree with the environmental context in which it develops. Halophytes, in general, are considered valuable resources in the ecosystems they inhabit due to their high abundance, persistence, natural reseeding capabilities, low nutrient demand, and greater tolerance to abiotic stresses (Yensen & Weber, 1985). These aspects have been considered for their use in animal feed in the northern region of the American continent but not in the rest of the Mesoamerican, Central, and South American regions that integrate the American continent (Barbosa *et al*., 2023).

The saline grass species identified as potential for animal feed starting from biomass production are *Sporobolus virginicus*, *D. spicata*, *Paspalum*, and *Kallar grass* with high biomass yield in salinity conditions (ICBA, 2006). In controlled conditions, some species as *A. lentiformis*, *Batis marítima,* and *Atriplex canescens* showed stable biomass productions from 800 to 1794 g

DRM m^2 year^{-1} when they were irrigated with seawater (Glenn & O´Leary, 1984) whereas *Atriplex lentiformis*, *Atriplex nummularia, Atriplex halimus*, and *Sporoborus* showing values of 25.0, 16.9, 14.6, a 29 t ha^{-1}, respectively (El-Shaer, 2010). On the other hand, *D. spicata* produced 1890 kg ha^{-1} DRM in salinity conditions (Sigua & Hudnall, 1991) and *D. spicata* accumulated 3975 kg ha^{-1} DRM in saline irrigation conditions in association with *S. indicus* (Al-Dakheel *et al*., 2006).

Table 2. Morphometric and productive characteristics of *Distichlis spicata* were collected in different sites on two coastlines, the Pacific Ocean and the Gulf of California in Baja California Sur, Mexico.

Coastlines	*D. spicata* condition	Plant longitude (cm)	Number of green leaves (U)	Number of nodes (U)	Stem width (cm)	Number of stems (U)	DRM yield (t ha^{-1})	DM yield (t ha^{-1})	Rangeland coefficient (ha AU year^{-1})
Pacific Ocean	Ds.S	14.2±1.37^c	12.05±1.08	6.33±0.70^c	1.16±0.07	1.16±0.09	0.88±0.09	0.26±0.04	5.66
	Ds.ARm	26.87±3.24^a	16.2±1.78	15±1.58^a	1.02±0.08	1.61±0.20	1.15±0.19	0.27±0.05	4.33
	Ds.AS	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
	Ds.A.Ev	17.52±2.08^b	11.8±1.84	7.66±0.89^c	1.24±0.07	1.44±0.24	0.84±0.03	0.19±0.01	5.93
Gulf of California	Ds.S	18.14±0.98^b	15.7±1.18	11.41±0.52^b	1.42±0.04	1.66±0.11	0.77±0.04	0.36±0.03	6.47
	Ds.ARm	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
	Ds.AS	16.1±1.18^b	18±1.69	13.71±2.19^{ab}	1.2±0.08	1.0±0.2	0.64±0.02	0.10±0.03	7.79
	Ds.A.Ev	21.21±1.41^{ab}	16.4±2.06	10.88±0.55^b	1.10±0.08	1.88±0.23	0.50±0.04	0.26±0.03	9.97
P		0.05	0.86ns	0.04	0.55ns	0.91ns	0.10ns	0.77ns	0.23ns
±SE		0.04	0.13	0.29	0.02	0.01	0.04	0.03	0.02

$^{a, b, c}$Average values with different letters in the same column differ statistically according to Scheffe. ±Deviation Standard; ±SE: Standard Error; (-): Grass condition not found in the coastal areas; ns= not statistically significant; DRM= dry matter DM= dead matter; Ds.S= *Distichlis spicata* growing alone; Ds.ARm= *D. spicata* associated with *R. mangle* spp.; Ds.AS= *D. spicata* associated to *Salicornia* spp.; Ds.A.Ev= *D. spicata* associated with other grass species.

The productivity values of *D. spicata* DRM and soil protective and erosion mitigating properties besides the background reported in halophytes evidence that *D. spicata* is considered a candidate species for developing a management system that allows scaling up biomass production in the state of Baja California Sur. However, this situation does not define its adoption by cattle raisers because some aspects are criteria to be considered, such use of soil, receptibility, acceptability by the productor, and adequate incentive provision to boost production (Leake *et al*., 2022).

Mineral profile, extraction, and nutrient incorporation of *Distichlis spicata* in natural growth conditions

The environmental impact analysis or ecological contribution of *D. spicata* showed significant differences within and between coastlines in function of the Pacific Ocean and Gulf of Mexico, starting from nutrient recycling by dead matter deposition and grass condition (alone or associated) (Table 3). *D. spicata* mostly incorporated Ca^{+2} and N in GCCL when growing alone, with respect to the condition associated within the same coastline, whereas in POCL growth condition only concentrated the lowest mineral incorporation. Nevertheless, the highest K^{+1}, Na^{+1}, $Fe^{+2,}$ and Mn^{+2} incorporation concentrated in POCL showed the lowest values in GCCL in growth conditions alone with respect to the rest in both coastlines (Table 3).

Nutrient extraction was centered on two minerals, Ca^{+2} and Na^{+1}. The plant extracts Ca^{+2} in the majority in GCCL when it grows alone with respect to the rest of the variants within and between coastlines while it maintains the same extracting response when it grows alone in POCL or associated with GCCL; whereas Na^{+1} is greatly extracted by grass when it grows alone in POCL with respect to its growth associated to the same coastline and in both growth conditions within the GCCL (Table 3). The *D. spicata* extraction/incorporation relationship (Table 3) showed that when grass grows alone in POCL, it extracts in weighted average of 0.20 % of Ca^{+2}, K^{+1}, Na^{+1}, and Mn^{+2} more than when it is associated, while in association with other grasses, it increases Mg^{+2}, Fe^{+2}, and P^{+3} extraction in 0.38 %. The presence of other grasses suggests a conditioning that modifies the mineral needs of *D. spicata* due to nutrient competence that predisposes energy inversion for growth in function of height and of the radicle system. In this respect, Mohammed *et al*. (2020) reported a vigorous root and rhizome growth of this plant that protects soils against erosion, and for the purpose of the present study, it means an improvement in mineral absorption that entails extracting more minerals than those incorporated. The response to this phenomenon in the GCCL was more passive. Grass in its condition only extracted 1 % more of Na^{+1} and Fe^{+2} with respect to associated growth. On the other hand, the association condition required approximately 0.50 % more than K^{+1} and P^{+3}, which means that coastlines with the characteristics that define them -but also influence grass mineral requirements- may be related to salinity levels and with-it growth rates and metabolic needs for plant development (Robertson *et al*., 2019).

Chemical composition, fibrous and nitrogenous fraction, and nutritional value of *D. spicata*

The chemical composition analysis of the fibrous fraction showed a similar response for both coastlines. Lignin content increased by 1 % in plants growing in GCCL whereas the nitrogenous fraction showed a 5 % increase in N content linked to fiber (ADF and NDF), but without manifesting crude protein content (CP) with only 5 % for plants that grow in both coastlines. The nutritional value also showed similar values for plants on both coastlines (Table 4).

The chemical composition and nutritional values of the halophyte plants are exposed to important intra- and inter-species (Kudoh *et al*., 2023) besides the soil factor, management system, productivity, palatability, and seasonal climate changes (Di Bella *et al*., 2019). The crude protein ranges reported by El-Shaer (2010) from 3.38 to 15 %, while fiber digestibility was ≥70 % in plants cultivated and <40 % in wild-growth plants, representing net and metabolizable energy contribution from 2.5-4.0 to 5-8 MJ kg^{-1} DRM^{-1}, respectively.

The CP values obtained in the present study for both coastlines are in the range pointed out by Al-Dakheel *et al*. (2006) and El-Shaer (2010) and agree with that reported by Escobar-Hernández *et al*. (2005) in a study with *D. spicata* in Baja California Sur, México. In other halophyte Gramineae studies with forage potential as *Atriplex* spp reported CP values from 14-20 % to ~65 % digestibility (Barbosa, 2020). In *Pappophorum caespitosum* -another grass with forage value located in the northwestern plain of Chaca-Pampa, Argentina- reported contents from 9-10 % CP (Pensiero *et al*., 2021) and in *Sporoborus rigens* the average values reported were CP from 3-5 %; ADF 41-43 % and for *S. indicus* CP 6 %; ADF 45 % and NDF 72 % (Barbosa *et al*., 2023).

In this sense, it is important to mention that CP <7 % values generate unbalance in N metabolism and ruminal microflora development (Rosales & Sánchez-Pinzón, 2005). Thus, according to the results obtained in the present study, alternatives such as supplementation and biofertilization within the grass production system would be necessary with the purpose of improving chemical composition and nutritional value.

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Table 3. Incorporation and extraction of minerals in leaf tissues of *Distichlis spicata* depending on growth condition (alone or associated) in two coastlines (Pacific Ocean and Gulf of California) of Baja California Sur, Mexico.

Coastlines	*D. spicata* condition	Ca^{+2}	Mg^{+2}	K^{+1}	Na^{+1}
		[1]**Nutrients incorporation (%)**			
Pacific Ocean	*Ds.S*	31.89±20.20^{c}	27.56±20.57^{b}	54.08±21.97^{a}	185.99±105.56^{a}
	Ds.A.Ev	30.12±22.13^{c}	29.84±22.03^{b}	57.62±24.48^{b}	174.2±109.33^{b}
Gulf of California	*Ds.S*	65.85±50.62^{a}	25.66±17.49^{b}	27.40±17.50^{c}	89.93±80.31^{d}
	Ds.A.Ev	44.60±41.84^{b}	41.92±17.88^{a}	29.48±12.79^{c}	159.99±80.10^{c}
P		0.05	0.01	0.02	0.03
±SE		0.15	3.90	0.85	17.83
		[2]**Nutrients extraction (ha^{-1})**			
Pacific Ocean	*Ds.S*	19.47±12.05^{b}	11.88±10.20	58.63±18.19	98.74±61.68^{b}
	Ds.A.Ev	14.81±12.91^{c}	20.96±10.64	54.95±21.49	106.25±67.53^{a}
Gulf of California	*Ds.S*	29.46±15.97^{a}	19.47±7.75	46.91±17.90	68.16±46.43^{c}
	Ds.A.Ev	19.75±14.23^{b}	27.67±7.41	53.78±14.61	96.20±46.66^{b}
P		0.03	0.89	0.55	0.03
±SE		2.60	2.69	1.87	7.23
		[3]**Relation extraction/incorporation nutrients**			
Pacific Ocean	*Ds.S*	0.68±0.73	0.56±0.39	1.25±0.82	0.78±1
	Ds.A.Ev	0.53±0.82	0.76±0.31	1.08±0.46	0.67±0.58
Gulf of California	*Ds.S*	0.68±0.55	0.84±0.32	1.87±0.79	1.15±0.79
	Ds.A.Ev	0.51±0.14	0.86±0.29	2.19±0.68	0.77±0.87
P		0.96	0.59	0.49	0.71
±SE		0.05	0.04	0.09	0.10

For mineral [1]incorporation and [2]extraction Mn^{+2} was transformed by $Arcsine = \sqrt{\frac{x}{100}}$, [3] and for relation extraction/incorporation by $log_n = (x+1)$, similar for Fe^{+2}. SE: standard error. Average values with different letters in the same column differ statistically according to Scheffe ($p \leq 0.05$). Ds.S = *D. spicata* growing alone; Ds.A.Ev = *D. spicata* associated to grass.

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Table 3. Incorporation and extraction of minerals in leaf tissues of *Distichlis spicata* depending on growth condition (alone or associated) in two coastlines (Pacific Ocean and Gulf of California) of Baja California Sur, Mexico.

Coastlines	*D. spicata* condition	Fe^{+2}	Mn^{+2}	P^{+3}	N^{-3}
		[1]**Nutrients incorporation (%)**			
Pacific Ocean	*Ds.S*	18.92±8.88[a]	0.28±0.15[a]	6.70±1.46	64.42±22.91[c]
	Ds.A.Ev	8.59±6.50[d]	0.03±0.12[c]	7.05±2.07	71.07±33.47[b]
Gulf of California	*Ds.S*	14.70±9.83[bc]	0.08±0.13[b]	7.56±3.02	83.91±22.95[a]
	Ds.A.Ev	11.33±7.25[cd]	0.01±0.12[c]	4.62±2.11	74.65±21.08[b]
P		0.05	0.05	0.24	0.05
±SE		2.13	0.01	0.75	2.65
		[2]**Nutrients extraction (ha^{-1})**			
Pacific Ocean	*Ds.S*	3.76±5.55	0.11±0.09	3.68±3.60	-
	Ds.A.Ev	5.09±5.55	0.01±0.09	7.01±2.40	-
Gulf of California	*Ds.S*	9.87±4.75	0.07±0.09	8.68±3.06	-
	Ds.A.Ev	5.92±3.72	0.04±0.08	7.86±2.56	-
P		0.19	0.35	0.14	-
±SE		1.03	0.01	0.66	
		[3]**Relation extraction/incorporation nutrients**			
Pacific Ocean	*Ds.S*	0.32±3.54	0.59±0.47	0.53±0.47	-
	Ds.A.Ev	0.74±0.79	0.01±0.46	1.04±0.34	-
Gulf of California	*Ds.S*	1.71±2.66	0.19±0.39	1.26±0.52	-
	Ds.A.Ev	0.62±3.27	0.04±0.30	1.71±0.40	-
P		0.32	0.07	0.07	-
±SE		0.08	0.08	0.15	

For mineral [1]incorporation and [2]extraction Mn^{+2} was transformed by $Arcsine = \sqrt{\frac{x}{100}}$, [3]and for relation extraction/incorporation by $log_n = (x+1)$, similar for Fe^{+2}. SE: standard error. Average values with different letters in the same column differ statistically according to Scheffe ($p \leq 0.05$). Ds.S = *D. spicata* growing alone; Ds.A.Ev = *D. spicata* associated to grass.

In the analysis of the cell wall constituents, similarities among them (Hcel, CEL, and LIG), as well as ash content (AIA) were shown in the ADF and NDF expressions. The values of the cell wall constituents are considered as fingerprints or the ordering pattern of the cell wall constituents of tropical Gramineae (Ledea-Rodríguez *et al*., 2018), which predisposes a low digestibility (<50 %), low protein content and fiber contents higher than >70 % (Rosales & Sánchez-Pinzón, 2005) similar that observed for *D. spicata*.

Digestibility and protein contents may be modified by the management systems that consider grass age, biofertilization, and irrigation systems to condition ADF and NDF values and with it the nutritional forage value (Abd El-Hack *et al*., 2018). These types of strategies were developed by Horvant (2002) concluding that when *D. spicata* is valued in its tender state, its chemical values improve, increasing the crude protein and reducing fiber content. Likewise, favorable responses have been reported at a productive level when nitrogenous fertilization is applied (Hill *et al*., 2018).

Table 4. Cell wall fractionation and nutritional value of *Distichlis spicata* in two coastlines (Pacific Ocean and Gulf of California) in Baja California Sur, Mexico.

Coastlines	Fibrous fraction (%))					
	NDF	ADF	Hcel	IAAD	CEL	LIG
Pacific Ocean	64.26±4.06	33.92±2.44	31.08±2.80	4.50±1.86	29.91±1.76	1.76±0.36
Gulf of California	66.80±4.68	35.72±3.05	30.07±6.98	4.17±2.38	31.40±2.63	2.24±1.18
P	0.22	0.18	0.73	0.74	0.18	0.31
±SE	1.17	0.83	0.43	0.15	0.68	0.22
	Nutritive value					
	DRM (%)	DDRM (%)	OMD (%)	ME (kcal kg DRM^{-1})		
Pacific Ocean	63.75±14.34	42.21±1.79	41.50±1.45	1398.28±54.19		
Gulf of California	67.43±9.72	41.09±2.06	40.32±1.96	1354.27±73.13		
P	0.47	0.22	0.16	0.16		
±SE	1.69	0.51	0.54	20.25		

NDF= Neutral detergent fiber; ADF= Acid detergent fiber; Hcel= Hemicellulose; IAAD= Insoluble ash in acid detergent; CEL= Cellulose; LIG= Lignin; N= Nitrogen; N-NDF= Nitrogen linked to neutral detergent fiber; N-ADF= Nitrogen linked to acid detergent fiber; CP= Crude protein; DRM= Dry matter; DDRM= Dry matter digestibility; OMD= Organic matter digestibility; ME= Metabolic energy; NLE= Net lactation energy; NFE: Net fattening energy; ±SE: Standard error.

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Table 4. Cell wall fractionation and nutritional value of *Distichlis spicata* in two coastlines (Pacific Ocean and Gulf of California) in Baja California Sur, Mexico.

Coastlines	Nitrogenous fraction (%)			
	N^{-3}	N-NDF	N-ADF	CP
Pacific Ocean	0.87±0.43	50.72±27.58	7.06±14.42	5.46±2.71
Gulf of California	0.91±0.50	45.03±26.71	3.61±7.96	5.66±3.12
P	0.12	0.10	0.07	0.66
±SE	0.012	0.10	0.12	0.26
	Nutritive value			
	NLE (kcal kg DRM^{-1})		NFE (kcal kg DRM^{-1})	
Pacific Ocean	703.6±61.97		556.63±47.27	
Gulf of California	708.48±42.36		518.24±63.80	
P	0.16		0.17	
±SE	14.27		17.66	

NDF= Neutral detergent fiber; ADF= Acid detergent fiber; Hcel= Hemicellulose; IAAD= Insoluble ash in acid detergent; CEL= Cellulose; LIG= Lignin; N= Nitrogen; N-NDF= Nitrogen linked to neutral detergent fiber; N-ADF= Nitrogen linked to acid detergent fiber; CP= Crude protein; DRM= Dry matter; DDRM= Dry matter digestibility; OMD= Organic matter digestibility; ME= Metabolic energy; NLE= Net lactation energy; NFE: Net fattening energy; ±SE: Standard error.

The fiber fraction analysis performed by the PCA (Figure 4) suggests a greater variability in the function of the vector longitude, great variability in PH, DRM, NDF, lignin, cellulose, and ADF contents, and very little variability in DRM and DM, ash content, stem longitude, green leaf number, and hemicellulose yield. On the other hand, the cosine angle opening pointed out a strong correlation between two groups that are found in a sagittal plane at both sides of the chart. Likewise, hemicellulose, DRM yield, stem number and longitude, ash, and number of green leaves were found within the closest points of origin of grass condition, which confirms that within the prospective study and the characterization developed, these last variables are the greatest weight in the description or expression of the rest of the variables considered for the present study.

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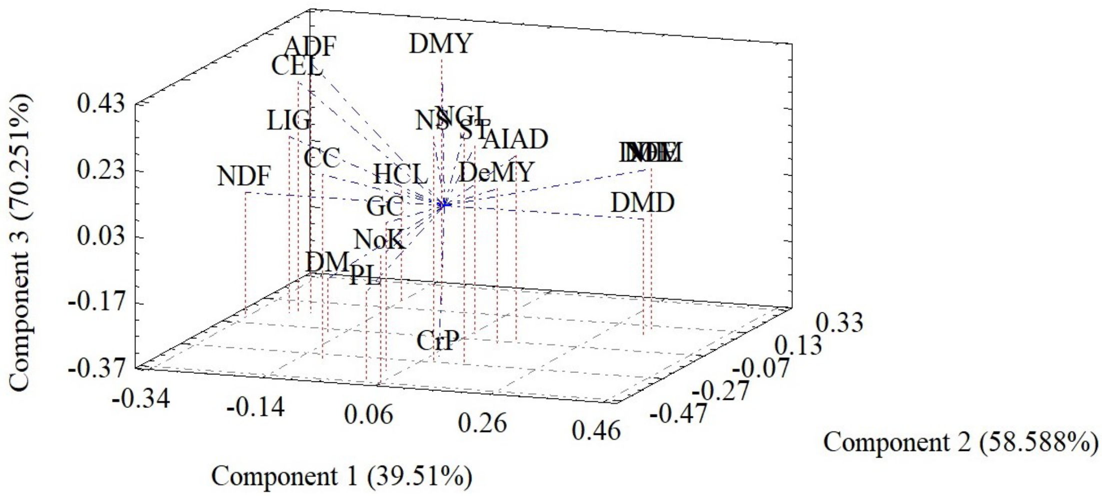

Figura 4. Análisis de componentes principales (ACP) mediante gráficos de pesos de componentes para variables morfo-productivas y químicas de *Distichlis spicata* colectado en dos litorales costeros (Océano Pacífico y Golfo de California) en Baja California Sur, México.

CL: Coastline; GC: Grass condition; ST: Stem thickness; SN: Stem number; NN: node number; PH: Plant height; GLN: Green leaf number; RtoDRM: Dry matter yield; RtoDM: Dead matter yield; CF: Crude protein; DRM: Dry matter; NDF: Neutral detergent fiber; ADF: Acid detergent fiber; HCL: Hemicellulose; IAAD: Insoluble ash in acid detergent; CEL: Cellulose; LIG: Lignin; DRM: Digestible dry matter; OMD: Organic matter digestibility; ME: Metabolizable energy; NLE: Net lactation energy; NFE: Net fattening energy.

In mineral extraction and incorporation analyses and their relationship, variability was obtained for all the correlated variables according to the angle cosine amplitude, coastal area, and grass extraction condition. The incorporation of Ca^{+2} favored the incorporation/extraction relationship of K^{+1} and P^{+3}, which indicates that these minerals are the most variable within each coastline, and their incorporation by the plant is directly related to the coastal grass with which it grows. The rest of the minerals showed an antagonistic-synergistic relationship for extraction and incorporation by the same plant (Figure 5).

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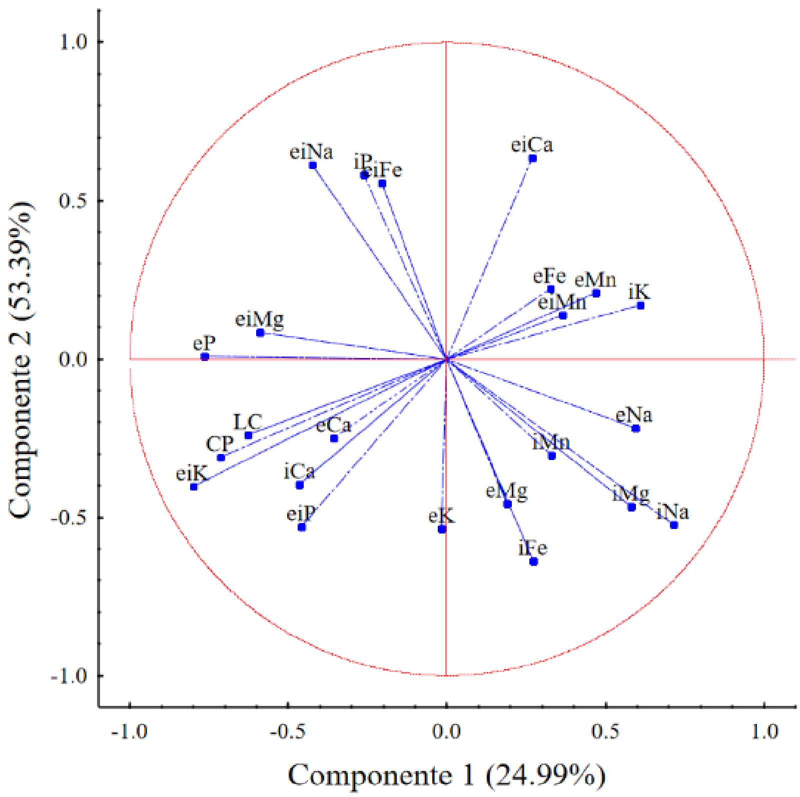

Figure 5. Values of components for mineral extraction and incorporation through *Distichlis spicata* leaf litter collected in two coastlines (Pacific Ocean and Gulf of California) in Baja California Sur, Mexico.

CL: Coastline; GC: Grass condition; eCa^{+2}: Calcium extraction; eMg^{+2}: Magnesium extraction; eK^{+1}: Potassium extraction; eNa^{+1}: Sodium extraction; eFe^{+2}: Iron extraction; eMn: Manganese extraction; eP^{+3}: Phosphorus extraction; iCa^{+2}: Calcium incorporation; iMg^{+2}: Magnesium incorporation; iK^{+1}: Potassium incorporation; iNa^{+1}: Sodium incorporation; iFe^{+2}: Iron incorporation; iP^{+3}: Phosphorus incorporation; eiCa^{+2}: Calcium incorporation/extraction; eiMg^{+2}: Magnesium incorporation/extraction; eiK^{+1}: Potassium incorporation/extraction; eiNa^{+1}: Sodium incorporation/extraction; eiFe^{+2}: Iron incorporation/extraction; eiMn^{+2}: Manganese incorporation/extraction; eiP^{+3}: Phosphorus incorporation/extraction.

Most of the minerals showed lower extraction variability with respect to plant incorporation. Mineral extraction may be related to plant requirements and availability that are maintained stable along its growth and development, provided that the coastline or plant growth condition constitutes a factor that determines any special condition. For example, competence for nutrients or stress by defoliation variables starts from the type of mineral (mobile or motionless) and intervention of the plant metabolic processes.

Conclusions

Distichlis spicata habitat is found along the coastline (both the Pacific Ocean and Golf of California), comprising Baja California Sur, México, where the Pacific is located at the level of dunes, whereas the Gulf is part of the coastal grass vegetation and wetlands, and in both, other grasses can be found growing alone. The coastal zone – jointly with the growth conditions (associated or alone) – influences grass length. However, it does not impact its morphometry and dry material accumulation. The morphometric and productive aspects suggest a forage aptitude, while its chemical composition is characterized by the bromatological pattern of the consistent tropical Grammineae in high fiber contents and low ones in protein and ruminal degradability. However, no predisposition exists to vary growth conditions within each coastline. *D. spicata* is affected greatly by growth conditions and mineral incorporation through dead leaves according to the coastline, while Ca^{+2} and Na^{+1} are centered in their extraction. Further studies should be performed to confirm forage suitability.

Authors' contributions

Conceptualization of the research study: JLLR and BMA; methodology development JLLR and ETD; software management JAAQ; experimental validation BMA and ETD; analyses of the results, JLLR; data management JAAQ; writing and manuscript preparation JLLR; writing, revision, and edition BMA, ETD and JAAQ.; project administration BMA; funding acquisition ETD. All the authors of this manuscript have read and accepted its published version.

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Ethical declarations

Does not apply.

Conflict of interest

The authors declare no conflict of interest.

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