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DISTRIBUTION AND BIOMASS OF *RUPPIA FILIFOLIA* (PHIL.) SKOTTSBERG, (RUPPIACEAE) IN SKYRING SOUND, SUB-ANTARCTIC ECOREGION OF MAGALLANES, CHILE

DISTRIBUCIÓN Y BIOMASA DE *RUPPIA FILIFOLIA* (PHIL.) SKOTTSBERG, (RUPPIACEAE) EN EL SENO SKYRING, ECOREGIÓN SUBANTÁRTICA DE MAGALLANES, CHILE

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RESUMEN

*Ruppia filifolia* es el pasto marino con la distribución más austral del planeta y del que se desconoce incluso los aspectos más básicos de su biología y ecología. Se evalúa la presencia, distribución batimétrica y biomasa alcanzada por las praderas *R. filifolia* en seno Skyring (ecoregión subantártica de Magallanes, Chile) mediante prospección remota con una cámara de video, y verificación directa y muestreo por buceadores. El litoral del seno Skyring está rodeado por praderas fragmentadas de *R. filifolia* hasta una profundidad de 5,3 m en bandas de 100-160 m de anchura. *R. filifolia* alcanza una biomasa de 80 g peso seco m<sup>-2</sup> con una asignación relativa de biomasa a rizomas más raíces frente a hojas de 1,6 a 1,9 y una densidad de 2.000 haces foliares m<sup>-2</sup>. Se discute la importancia de este pasto marino en el funcionamiento del ecosistema costero somero del seno Skyring.

Palabras clave: pastos marinos, ambientes sub-antárticos.

ABSTRACT

*Ruppia filifolia* is the seagrass with the world's southernmost distribution and a species about which even the most fundamental aspects of its biology and ecology are not known. Presence, bathymetric distribution, and biomass of *R. filifolia* meadows in Skyring sound (sub-antarctic ecoregion of Magallanes, Chile) were evaluated through a remotely operated vehicle (ROV) survey, and direct verification and sampling by divers. The littoral of Skyring sound is surrounded by patchy *R. filifolia* meadows to a depth

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of 5.3 m in bands 100-160 m wide. *R. filifolia* achieved a biomass of 80 g dry weight m<sup>-2</sup>, a rhizomes plus roots to leaves biomass ratio of 1.6 to 1.9 and a density of 2.000 shoots m<sup>-2</sup>. Possible relevance of meadows formed by this seagrass species in the functioning of the shallow coastal ecosystem of Skyring sound is discussed.

Key words: seagrasses, sub-antarctic environments.

## INTRODUCTION

The genus *Ruppia* includes monocotyledoneous aquatic plants with cosmopolitan distribution that live in freshwater, brackish, and marine and continental salt waters (den Hartog, 1981). The high morphological variability shown by *Ruppia* plants determines that the taxonomy at the species level is not definite yet, and *Ruppia maritima* L. is considered as the type species of the genus (den Hartog & Kuo, 2006). *Ruppia filifolia* (Phil.) Skottsberg is endemic of the Andean mountain range (den Hartog, 1981) and the seagrass with the world's southernmost distribution (Ramírez *et al.*, 1979; Short *et al.*, 2007). Recent molecular phylogenetic analyses (Ito *et al.*, 2010) distinguish *R. filifolia* as a separate entity from other *Ruppia* species.

*Ruppia filifolia* is present in brackish coastal wetlands in Los Chonos archipelago (South Chile: Álvarez *et al.*, 2010; San Martín *et al.*, 2011), in Skyring sound (sub-antarctic ecoregion of Magallanes: Skottsberg, 1916; Mazzella & Gambi, 1993), and in certain freshwater creeks and brackish coastal lagoons in Tierra del Fuego and Falkland Islands (Moore, 1973, 1983). Except for some phenological notes (flowers are found in December and January in the Falkland Islands: Moore, 1983) no other information about the life cycle, biomass and extent of the meadows formed by this species is available. Hence, the role that this species might have in the functioning of the ecosystem remains to be elucidated. However, a recent study (Cañete *et al.*, 2012) reports the presence of a 1200 m<sup>2</sup> meadow of *R. filifolia* in the north shore of Skyring sound. *Ruppia* meadows attenuate waves and reduce the concentration of suspended particulated matter and chlorophyll (Ward *et al.*, 1984; Mannino & Sarà, 2006), and provide habitat and food to other organisms (Verhoeven, 1980a, 1980b; Ward, 1983; Dunton, 1990; Mannino &

Sàrà, 2006; López-Calderón *et al.*, 2010).

This study evaluates the extent and biomass of *R. filifolia* meadows in Skyring sound, a coastal system where this species is abundant (Skottsberg, 1916). The goals of the study are 1) to verify the presence, 2) to determine the upper and lower limits of the bathymetric distribution, and 3) to estimate the biomass of *R. filifolia* meadows.

## MATERIAL AND METHODS

### Study site

Skyring sound (52°30' S, 73°00' W and 53°40' S, 71°30' W), located Northwest of Punta Arenas (Chile), is a approximately 100-km fjord connected to Magallanes strait through Gajardo channel in the West, and through Fitz Roy channel, Otway sound and Jerónimo channel in the East (Fig. 1). Air temperature varies between 1.5° C (average of daily minima) and 8.6° C (average of daily maxima), the average daily solar radiation is 116 W m<sup>-2</sup>, annual rainfall is 988 mm year<sup>-1</sup> and dominant winds from West and Northwest with velocities of 3.7 m s<sup>-1</sup> (average) and 8.8 m s<sup>-1</sup> (average of the maxima) (Schneider *et al.*, 2003). The temperature of surface water varies between 4.5° C in winter and 10.5° C in summer, surface water salinity is 18 (psu) and dissolved oxygen concentration is always above 8 ml l<sup>-1</sup> (Kilian *et al.*, 2007).

Presence, extent and bathymetric distribution of *R. filifolia* meadows

Meadow detection was achieved using a "Fast Observer" (Mariscope Meerestechnik, Kiel, Germany) remotely operated vehicle (ROV) and also through direct observation by divers. Three locations in the

<sup>1</sup> Ward, D.H., (1983). *The relationship of two seagrasses: Zostera marina and Ruppia maritima to the black brant Branta bernicla nigricans, San Ignacio Lagoon, Baja California, México.* Master of Science Thesis, University of Oregon.

north coast of Skyring sound where *R. filifolia* fragments were deposited in the beach were surveyed in autumn (April-May 2001) using the ROV (Fig. 1). Bottom images were obtained by the VHS video camera (Phillips) that the ROV includes and visualized live on-board using a 14" display (Phillips). A depth meter included in the ROV allowed knowing the acquisition depth of bottom images.

The ROV survey was completed with another survey in spring (November 2011) where the presence of *Ruppia filifolia* fragments in the beach cast (i.e., deposited in the beach) was assessed every 5-10 km between Río Pérez and Rocallosa point (Fig. 1). Divers verified the presence of *R. filifolia* meadows in 11 of the locations where the beach cast contained *R. filifolia* fragments and registered the depth of the upper and lower bathymetric limits of the meadows in 5 of those locations. Divers marked also the position of the upper and lower bathymetric limits of *R. filifolia* meadows in 2 of those locations using a Garmin GPS 12 receiver. The distance (in m)

between the upper and lower bathymetric limits of *R. filifolia* meadows was calculated using the ruler tool of Google Earth™ after inserting the coordinates of the bathymetric limits in the software.

#### Biomass of *R. filifolia* meadows

Biomass of *Ruppia filifolia* was assessed through the collection of 7 samples (April 2001) and 5 samples (December 2004), all in Río Pérez (Fig. 1), using a 30 cm in diameter stainless steel corer that was inserted to a depth of 40 cm in meadow sediment by divers. The samples were washed manually to eliminate sediment and detritus. The number of *R. filifolia* shoots was counted in the 2001 samples to estimate the shoot density of the meadow (number of shoots per m<sup>2</sup>). *R. filifolia* biomass in each sample was fractioned into leaves, rhizomes and roots and dried at 70 °C during 48 hours to estimate its dry weight (D.W.).

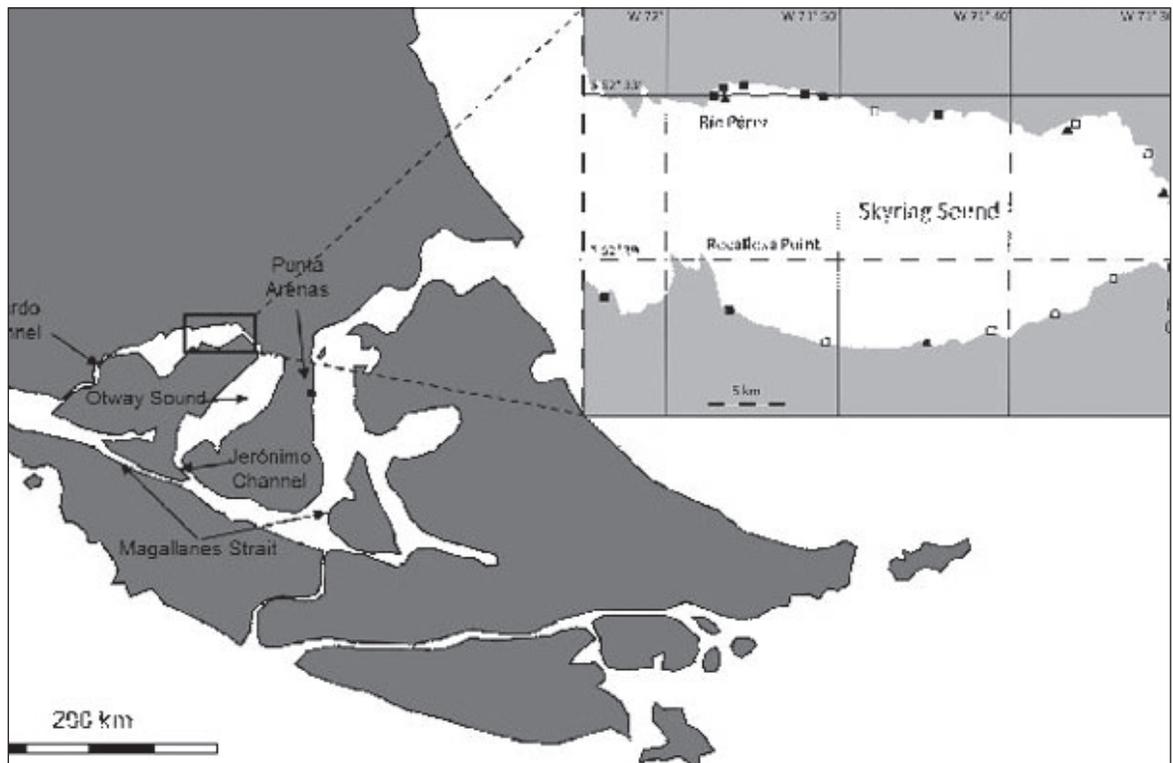


Fig. 1. Presence of *Ruppia filifolia* meadows in Skyring sound (sub-antarctic ecoregion of Magallanes, Chile) verified either using a ROV (triangles, 2001) or direct observation by divers (black squares, 2011). White squares indicate locations where fragments of *R. filifolia* were found deposited in the beach in 2011 but presence of meadows was not verified.

Table 1. Shoot density and biomass (dry weight, D.W.) of *Ruppia filifolia* in Skyring sound (sub-antarctic ecoregion of Magallanes, Chile). Average  $\pm$  1 standard error.

Variables	April 2001	December 2004
Shoot density (shoots m <sup>-2</sup> )	2017 $\pm$ 417	Not evaluated
Leaf biomass (g D.W. m <sup>-2</sup> )	31.5 $\pm$ 3.4	27.2 $\pm$ 3.4
Rhizome biomass (g D.W. m <sup>-2</sup> )	28.3 $\pm$ 3.4	27.8 $\pm$ 2.1
Root biomass (g D.W. m <sup>-2</sup> )	22.3 $\pm$ 4.7	24.6 $\pm$ 4.5
Total biomass (g D.W. m <sup>-2</sup> )	82.1 $\pm$ 10.2	79.6 $\pm$ 3.8

## RESULTS

### Presence, extent and bathymetric distribution of *R. filifolia* meadows

The beach cast in Skyring sound contained fragments of *Ruppia filifolia* in all the locations that were surveyed. The presence of *R. filifolia* meadows was verified either through ROV video images or directly by divers in 14 locations, that is, in all the locations where the verification was done. *R. filifolia* meadows are not continuous but fragmented in patches of diverse shapes and sizes that extend from a depth of 30 cm to depths of 4 – 4.5 m in the north shore and to depths of 4.5 – 5.3 m in the south shore of Skyring sound (Fig. 1). The width of the band where *R. filifolia* patches are present varies between 100 m and 160 m.

### Biomass of *R. filifolia* meadows

The biomass of *Ruppia filifolia* was about 80 g D.W. m<sup>-2</sup> (Table 1). The biomass assigned to rhizomes and roots was always higher than that assigned to leaves (Fig. 2) reaching the rhizomes plus roots to shoot ratio a value of 1.6 in April 2001 and 1.9 in December 2004. Shoot density was about 2000 shoots m<sup>-2</sup> in April 2001 (Table 1).

## DISCUSSION

Our results show that *Ruppia filifolia* is present throughout all the shore of the Eastern half of Skyring sound (from Río Pérez to Rocallosa point) where it forms patchy meadows between the depths of 0.3 m and 5.3 m in bands 100-160 m wide. The ancient Skottsberg (1916) reference to the abundance of *R. filifolia* in Mina Magdalena (south shore of Skyring

sound) and in Caleta Los Amigos (near the mouth of Fitz Roy channel) is therefore supported by present-day data. Our results support also previous single-location records of the presence of *R. filifolia* in the northern shore of Skyring sound (Mazzella & Gambi, 1993; Cañete *et al.*, 2012). Additionally, the similarity between the depth reported by Skottsberg (1916) of *R. filifolia* in Mina Magdalena (5 m) and that found by us in the southern shore of Skyring sound in present days (4.5-5.3 m) suggests that the bathymetric distribution of the species and, perhaps, the transparency of the water column might have remained unchanged during the last century.

The vegetative development achieved by this species in sub-antarctic environmental conditions is somewhat lower than that showed by other *Ruppia* species in temperate and Mediterranean environments. The shoot density of *R. filifolia* meadows in Skyring sound is in the lower end of the range of values found in meadows of *R. maritima* (0 - 40,000 shoots m<sup>-2</sup> Dunton, 1990; 4644 - 6922 shoots m<sup>-2</sup> Cho & Poirrier, 2005; 200 - 1,900 shoots m<sup>-2</sup> López Calderón *et al.*, 2010) and *R. cirrhosa* (372 shoots m<sup>-2</sup> Kautsky, 1991; 2,900 - 3,700 shoots m<sup>-2</sup> Mannino & Sára, 2006; 3,300 - 16,400 shoots m<sup>-2</sup> Pergent *et al.*, 2006). The biomass of *R. filifolia* meadows in Skyring sound is also in the lower end of the range of values found in meadows of *R. maritima* (1 - 35 g D.W. m<sup>-2</sup> Orth & Moore, 1988; 0 - 300 g D.W. m<sup>-2</sup> Dunton, 1990; 0 - 187 g D.W. m<sup>-2</sup> Da Silva & Asmus, 2001; 200-600 g D.W. m<sup>-2</sup> Cho & Poirrier, 2005) and *R. cirrhosa* (60 - 226 g D.W. m<sup>-2</sup> Verhoeven, 1980b; 150 - 330 g D.W. m<sup>-2</sup> Pérez & Camp, 1986; 90 - 485 g D.W. m<sup>-2</sup> Calado & Duarte, 2000). The relative allocation of *R. filifolia* biomass to rhizomes plus roots and leaves is, however, similar to that of *R. maritima* (1.7, Dunton, 1990). Recent data about biomass of *R. filifolia* in Skyring sound,

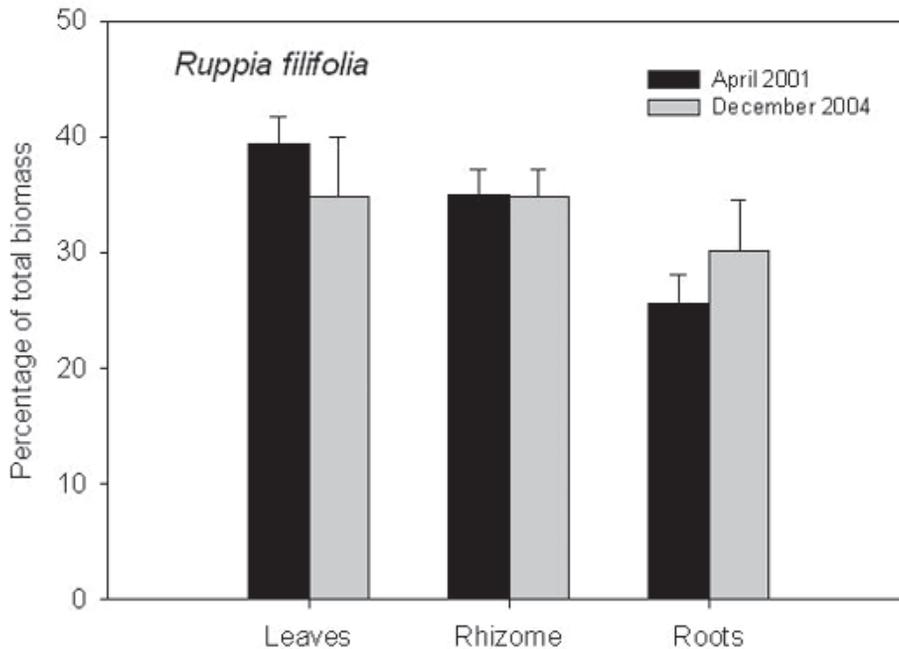


Fig. 2. Percentage (average + 1 standard error) of total biomass of *Ruppia filifolia* allocated to leaves, rhizomes and roots in Skyring sound (sub-antarctic ecoregion of Magallanes, Chile).

between 1.7 and 2.5 kg for a section of 18.75 l of meadow sediment (Cañete *et al.*, 2012) are not standard or comparable to our data because they correspond to a fresh weight that includes the weight of the sediment. Altogether our results suggest that the vegetative development achieved by *R. filifolia* in sub-antarctic environmental conditions is lower than that achieved by other species of *Ruppia* in other environments.

The presence of patchy meadows of *Ruppia filifolia* in bands 100-160 m wide and up to a depth of about 5 m throughout all the shore of the Eastern half of Skyring sound suggests that this species might have a relevant role in the functioning of the shallow coastal ecosystem of the sound. The role of this species under sub-antarctic environmental conditions might be similar to that played by other species of *Ruppia* in other environments: promotion of biodiversity through the provision of habitat and food to other organisms (Verhoeven, 1980a, 1980b; Ward, 1983; Dunton, 1990; Mannino & Sarà, 2006; López-Calderón *et al.*, 2010), or the attenuation of waves and the reduction of the concentration of

suspended particulated matter and chlorophyll in water (Ward *et al.*, 1984; Mannino & Sarà, 2006). This hypothesis has also been recently stated by Cañete *et al.* (2012). *R. filifolia* is an under-studied aquatic plant because most knowledge available until now refers to the general type of habitat where it is present (freshwater creeks and brackish lagoons and sounds in Austral South America: Skottsberg, 1916; Moore, 1973, 1983; Mazzella & Gambi, 1993; Álvarez *et al.*, 2010; San Martín *et al.*, 2011) only. Skyring sound appears as an adequate system to initiate the study of the biology and ecology of the eurysaline aquatic plant with the southernmost distribution in the world.

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