

RESEARCH

Open Access



Zonation and soil factors of salt marsh halophyte communities

Jeom-Sook Lee¹, Jong-Wook Kim^{4*}, Seung Ho Lee², Hyeon-Ho Myeong³, Jung-Yun Lee⁴ and Jang Sam Cho⁵

Abstract

Background: The structures and soil factors of *Suaeda glauca*-*Suaeda japonica* zonal communities and *Phragmites australis*-*S. japonica* zonal communities were studied in salt marshes of west and south coasts of South Korea to provide basic data for coastal wetland conservation and restoration.

Results: *S. glauca* community mean length was 67 m and *S. japonica* community mean length was 567 m in zonal communities, and *P. australis* and *S. japonica* community mean length were 57 m and 191 m in zonal communities. Regarding the electrical conductivity, sodium content, and clay contents in Upnae-ri, Shinan-gun, there were significant differences among zonal communities at significance level of 0.05 for two-sided *t* test. However, other factors were not significantly different.

Conclusions: The results indicate that multiple factors such as electronic conductivity, total nitrogen level, clay, and sodium might play important roles in the formation of zonal plant communities of salt marshes.

Keywords: Zonation, Salt marsh plant, Soil factor, *Suaeda glauca*, *S. japonica*, *Phragmites australis*

Background

Zonal distribution of higher plants in salt marshes has been studied extensively for over a century. However, mechanisms of generating the segregation of salt marsh plant species are poorly understood (Caçador et al. 2007; Emery et al. 2001). In order to explain plant zonation, shore height is frequently used as an indicator of abiotic gradient in intertidal ecosystems. This is based on the implicit assumption that shore height is directly correlated with inundation frequency and/or duration (Bockelmann et al. 2002; Sánchez et al. 1996). The objective of this study was to determine structures of zonal communities and factors that might control salt marsh plant patterns and zonations.

Methods

The structures and soil factors of two zonal community types of South Korea were monitored and can be used as basic data for conservation and restoration of coastal wetland ecosystems (Fig. 1). Six *Suaeda glauca*-*Suaeda japonica* zonal communities (Table 1, No. 1–6 in 1998) and five *Phragmites australis*-*S.*

japonica zonal communities (Table 1, No. 1 in 1998, No. 2–3 in 2005, No. 5–6, 2015) were sampled from the west coast to the south coast of South Korea.

Results and discussion

S. glauca community mean length was 67 m and *S. japonica* community mean length was 567 m in zonal communities, and *P. australis* community mean length was mean 57 m and *S. japonica* community mean length was 191 m in zonal communities (Table 1). *S. glauca* community was found in Unpo-ri, Songhyun-ri, and Chulpo-ri. The community height was 70–80 cm. Its coverage in study areas was 70–80 %. The *S. japonica* community was found in both *S. glauca*-*S. japonica* and *P. australis*-*S. japonica* zonal communities. Its community height was 35–45 cm. Its coverage in study areas was 85–100 %. The area of salt marshes in Chulpo-ri and Sinduk-ri was 4–5 km². *P. australis* communities were found in Woopo-ri, Nongjoo-ri, and Dongkeom-ri. Community height was 64–125 cm with coverage of 85–100 %.

Soil factors in *S. glauca*, *S. japonica*, and *P. australis* communities of Upnae-ri, Shinan-gun, are shown in Fig. 2. Electrical conductivity \pm SE in *S. glauca*, *S. japonica*, and *P. australis* communities were 1.38 ± 0.0015 ,

* Correspondence: keco@mokpo.ac.kr

⁴Department of Biological Science, Mokpo National University, Muan-gun 58554, South Korea

Full list of author information is available at the end of the article



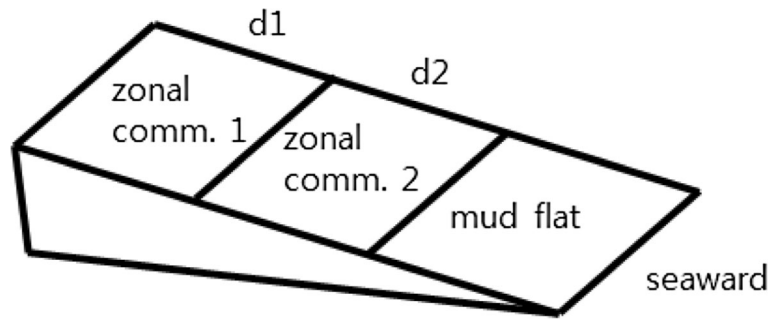


Fig. 1 The first community length of occupation ($d1$, m) and second community length of occupation ($d2$, m) in salt marsh

1.28 ± 0.0045, and 1.01 ± 0.0055 mS/cm, respectively ($n = 10$). Total nitrogen ± SE in *S. glauca*, *S. japonica*, and *P. australis* communities were 0.21 ± 0.0026, 0.55 ± 0.0026, and 0.69 ± 0.0025 mg/g, respectively ($n = 10$). Higher total nitrogen level in *S. japonica* community than that in *S. glauca* community might be due to higher density in *S. japonica* community. Higher total nitrogen level in *P. australis* community might be due to higher biomass in *P. australis* community. Total phosphate ± SE in *S. glauca*, *S. japonica*, and *P. australis* communities were 0.05 ± 0.0008, 0.04 ± 0.0009, and 0.04 ± 0.0005 mg/g, respectively ($n = 10$). Such slight difference might be due to dilution of inland and coastal wastewater by tide. Sodium contents ± SE in *S. glauca*, *S. japonica*, and *P. australis* communities were 15.3 ± 0.0137, 12.3 ± 0.0052, and 5.8 ± 0.0104 mg/g, respectively ($n = 10$). Clay content ± SE in *S. glauca*, *S. japonica*, and *P. australis* communities were 26.0 ± 0.0344, 25.0 ± 0.0446, and 8.0 ± 0.0274 mg/g, respectively ($n = 10$). Regarding the electrical conductivity, sodium content, and clay contents in both *S.*

glauca-*S. japonica* and *P. australis*-*S. japonica* communities and total phosphate in *S. glauca*-*S. japonica* community in Upnae-ri, Shinan-gun, there were significant differences among zonal communities at significance level of 0.05 for two-sided t test. However, there were little differences in total phosphate levels.

Conclusions

Halophyte distributions are related to multiple reactions of flooding and salinity concentrations (Benito et al. 1990; Caçador et al. 2007; Mert and Varder 1977). In South Korea, halophyte distributions have been determined for soil-water relation and soil texture (Ihm et al. 2007; Rogel et al. 2001) as well as flooding frequency (Lee 1990). A combination of multiple factors such as flooding, soil salinity, and competition have been suggested to play important roles in the formation of zonal plant communities in salt marshes (Pennings and Callaway 1992; Silvestri et al. 2005).

Table 1 Zonal community name, first community length of occupation, second community length of occupation ($d1$ and $d2$, m), locations of six *Suaeda glauca*-*S. japonica*, and five *Phragmites australis*-*S. japonica* zonal communities

Zonal community name	First community length $d1$ (m)	Second community length $d2$ (m)	Locations
<i>Suaeda glauca</i> - <i>S. japonica</i> 1	67	990	Kimje-gun Unpo-ri
<i>Suaeda glauca</i> - <i>S. japonica</i> 2	100	100	Kimje-gun Sopo-ri
<i>Suaeda glauca</i> - <i>S. japonica</i> 3	33	462	Buan-gun Songhyun-ri
<i>Suaeda glauca</i> - <i>S. japonica</i> 4	100	627	Buan-gun Chulpo-ri
<i>Suaeda glauca</i> - <i>S. japonica</i> 5	67	924	Kochang-gun Sinduk-ri
<i>Suaeda glauca</i> - <i>S. japonica</i> 6	33	297	Kochang-gun Wolsan-ri
Mean ± SD	67 ± 30	567 ± 350	
<i>Phragmites australis</i> - <i>S. japonica</i> 1	33	231	Yonggwang-gun Hasa-ri
<i>Phragmites australis</i> - <i>S. japonica</i> 2	55	210	Gangwha-gun Dongkeom-ri
<i>Phragmites australis</i> - <i>S. japonica</i> 3	17	118	Bosung-gun Jeonil-ri
<i>Phragmites australis</i> - <i>S. japonica</i> 4	144	216	Suncheon-gun Nongjoo-ri
<i>Phragmites australis</i> - <i>S. japonica</i> 5	36	180	Buan-gun Woopo-ri
Mean ± SD	57 ± 51	191 ± 45	

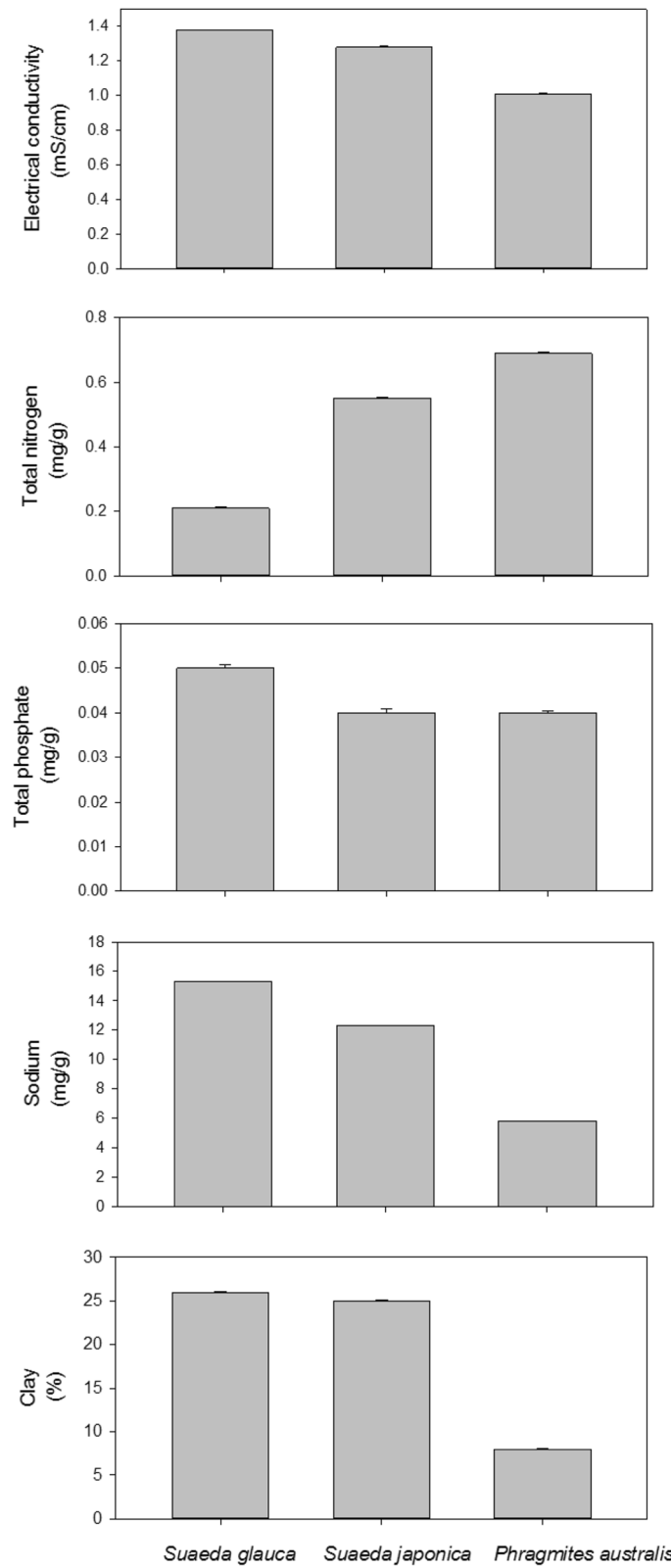


Fig. 2 Electrical conductivity, total nitrogen, total phosphate, sodium, and clay contents (mean \pm SE) in *S. glauca*, *S. japonica*, and *P. australis* communities in salt marshes of Upnae-ri, Shinan-gun

Acknowledgements

Emeritus Professor Byung-Sun Ihm deserves to be acknowledged for his ideas and comments on the manuscript at Mokpo National University, South Korea.

Funding

This research was funded with resources from Mokpo National University.

Availability of data and materials

Please contact author for data requests.

Authors' contributions

The study was designed by JSL and JWK. SHL, HHM, and JYL collected and analyzed the data. SHL has helped in the statistical analysis of the data. JWK and SHL has drafted the manuscript. All authors approved the final manuscript.

Competing interests

The authors declare that they have no competing interests.

Consent for publication

Not applicable.

Ethics approval and consent to participate

Not applicable.

Author details

¹Department of Biology, Kunsan National University, Gunsan 54150, South Korea. ²Marine & Environmental Research Laboratory, Ansan 15486, South Korea. ³Division of Ecosystem Research, National Park Research Institute, Wonju 26441, South Korea. ⁴Department of Biological Science, Mokpo National University, Muan-gun 58554, South Korea. ⁵Division of Ecological Assessment, National Institute of Ecology, Seocheon 33657, South Korea.

Received: 28 August 2016 Accepted: 14 September 2016

Published online: 24 October 2016

References

- Benito, I, Agirre, A, & Onaindia, M (1990). Zonation of halophytic vegetation along a tide exposure gradient and associated processes. *Anales de Biología*, 16, 163–175.
- Bockelmann, AC, Bakker, JP, Neuhaus, R, & Lage, J (2002). The relation between vegetation zonation, elevation and inundation frequency in a Wadden Sea salt marsh. *Aquatic Botany*, 73, 211–221.
- Caçador, I, Tibério, S, & Cabral, HN (2007). Species zonation in Corroios salt marsh in the Tagus estuary (Portugal) and its dynamics in the past fifty years. *Hydrobiologia*, 587, 205–211.
- Emery, NC, Ewanchuk, PJ, & Bertness, MD (2001). Competition and salt-marsh plant zonation: stress tolerators may be dominant competitors. *Ecology*, 82, 2471–2485.
- Ihm, B-S, Lee, J-S, Kim, J-W, & Kim, J-H (2007). Coastal plant and soil relationships in the southwestern coast of South Korea. *J Plant Biol*, 50, 331–335.
- Lee, J-S (1990). *On establishment of halophytes along tidal level gradient at salt marshes of Manhyong and Dongjin river estuaries*. South Korea, Seoul National University.
- Mert, HH, & Varder, Y (1977). Salinity, osmotic pressure, and transpiration relationships of *Salicornia herbaceae* in its natural habitats. *Phyton*, 18, 71–78.
- Pennings, SC, & Callaway, RM (1992). Salt marsh plant zonation: the relative importance of competition and physical factors. *Ecology*, 73, 681–690.
- Rogel, JÁ, Silla, RO, & Ariza, FA (2001). Edaphic characterization and soil ionic composition influencing plant zonation in a semiarid Mediterranean salt marsh. *Geoderma*, 99, 81–98.
- Sánchez, JM, Izco, J, & Medrano, M. (1996). Relationships between vegetation zonation and altitude in a salt-marsh system in northwest Spain. *Journal of Vegetation Science*, 7, 695–702.
- Silvestri, S, Defina, A, & Marani, M (2005). Tidal regime, salinity and salt marsh plant zonation. *Estuar Coast Shelf S*, 62, 119–130.

Submit your next manuscript to BioMed Central and we will help you at every step:

- We accept pre-submission inquiries
- Our selector tool helps you to find the most relevant journal
- We provide round the clock customer support
- Convenient online submission
- Thorough peer review
- Inclusion in PubMed and all major indexing services
- Maximum visibility for your research

Submit your manuscript at
www.biomedcentral.com/submit

