学 位 論 文 内 容 の 要 旨

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学 位 論 文 題 名

Variation in phenology, biological traits, and associated epifaunal community between native and non-native populations of the seagrass *Zostera japonica*
（海草コアマモの在来集団と移入集団の間における季節性、形質、葉上動物群集の変異）

Biological invasions, or human-mediated translocations of species to regions outside their native range, are increasing worldwide, including in seagrass ecosystems. Understanding of how seagrass and seagrass ecosystems respond to invasions are important not only for management and conservation of the ecosystem, but also provide opportunity to deepen our understandings on seagrass ecology in general. *Zostera japonica* is an intertidal seagrass native in Asia, with wide distribution extending from tropical to temperate regions. In addition to its native distribution, *Z. japonica* also occurs in North America, where it was introduced in the 1950s and has established its populations since then.

Because of its established non-native populations in North America, the impacts of *Z. japonica* introduction had been occasionally studied by comparing with its native populations in Asia, or by comparing with a native congener *Z. marina* in its introduced region, which is native in both Asia and North America. However, previous studies conducting native and non-native populations comparison cannot discriminate if observed difference arose from introduction effects or from regional differences, nor studies compared with native congener in introduced region alone cannot discriminate if observed difference arose from introduction effects or from species differences. In this thesis, I proposed a use of combined methods of native and non-native regional comparison with *Z. japonica* and *Z. marina* species comparison for robust investigation of *Z. japonica* introduction effects, independent from regional or species differences. The main objective of this thesis is to investigate introduction effects **ON** and **OF** *Z. japonica*, with special focuses on three aspects of seagrass ecosystems, (1) seagrass phenology, (2) seagrass biological traits and (3) seagrass-associated animal communities, which were examined in three independent chapters (Chapters 2 to 4).

In Chapter 2, I investigated the influence of abiotic factors on seagrass biomass and reproductive phenology of *Z. japonica*. By conducting a large-scale analysis covering tropical to temperate region and including both native and non-native populations, I found that phenological traits varied greatly among regions affected by abiotic factors,

such as latitude and temperatures, but results also varied among analyzed traits. While maximum biomass and peak reproductive timings were significantly affected by temperature for *Z. japonica* populations in general, growth durations and reproductive ratios were affected by latitude and only for non-native populations. These observed difference in responses between native and non-native indicate the presence of the introduction effects on seagrass phenology.

In Chapter 3, I conducted multi-site comparisons of seagrass biological traits of *Z. japonica* between native (Japan) and non-native (Canada) regions, along with those of *Z. marina* that is native in both regions. Results suggested that non-native *Z. japonica* showed constant shoot size, lower shoot density, leaf area index and biomass, and higher reproductive ratio compared to native populations, whereas *Z. marina* showed no regional difference in traits. Regional trait differences observed only for *Z. japonica* support that these differences are in fact induced by introduction. These results indicated that significant trait change occurred during the introduction of *Z. japonica* to North America, potentially through rapid evolution.

In Chapter 4, I compared epifaunal community associated with seagrass between *Z. japonica* and *Z. marina*, from multiple sites in Japan, where both seagrass species are native, and Canada, where *Z. japonica* is non-native. I found that epifaunal abundance were similar between native and non-native *Z. japonica*, whereas epifaunal diversity was lower for *Z. japonica* compared to *Z. marina*, only in Canada, and was equally diverse for both species in Japan. Additionally, while species-specific associated species-specific epifaunal community on native *Z. japonica* were distinct from that of *Z. marina*, species associated with non-native *Z. japonica* were mainly a subset of that on *Z. marina*, suggesting that non-native *Z. japonica* has not established its species-specific community in its introduced region. These results demonstrated that observed diversity reduction for non-native *Z. japonica* is caused by its non-native status and not by seagrass species identity.

From three independent studies shown above, I constantly found that non-native *Z. japonica* populations differ from native populations highlighting the significant introduction effects **ON** and **OF** *Z. japonica*. My study indicated that the non-native seagrass differs in their phenological and biological traits from native populations and hosts less diverse epifaunal community compared to the native congeneric species in the introduced region. Significant introduction effects suggested from this study pointed out the importance of accounting non-native seagrass differently from native seagrass for seagrass ecosystem management, which had been overlooked in seagrass ecology. Findings of this thesis contribute to deepen our understanding on invasion ecology and seagrass ecology in general, in addition to giving valuable implications on marine biodiversity conservation and ecosystem management.