結合棲地適宜性與入侵壓力以評估條紋小鮕的棲地偏好

Integrating Habitat Suitability and Invasion Pressure to Assess Habitat Preferences of the *Puntius semifasciolatus*

國立成功大學水利及海洋工程學系

碩士	教授	碩士生
王啓豪	孫建平	李耘寬
Wang,Chi-Hao	Jian-Ping Suen	Yun-Kuan Lee

摘　要

本研究旨在建構一套整合環境因子、競爭壓力與物種偏好的多層次棲地適宜性評估架構，應用於分析屏東五溝水濕地原生魚類——條紋小鮕（*Puntius semifasciolatus*）的空間分布與棲地適宜性。研究首先透過電格採樣與環境因子量測建立條紋小鮕的棲地適宜性指數並進一步導入外來種壓力、生態棲位重疊與競爭物種環境適應性等概念，依序建構四種模型架構，模擬不同生態假設下的棲地條件與競爭效應。在模型評估方面，本研究以 AUC 曲線結合限制分析檢視環境變數之組合辨識能力，並透過 Kruskal-Wallis 與 Dunn's 無母數檢定，比較施工干擾前後各模型的評分差異，以評估工程事件對棲地適宜性評分之影響。另外以線性混合效應模型預測隔年條紋小鮕豐度變異，並計算邊際與條件決定係數，評估各模型對條紋小鮕動態之解釋能力。結果顯示，模型 A 具穩定性與操作簡便特性，可有效反映總生物量壓力；模型 B 於外來種影響顯著區域表現良好，適合應用於入侵壓力監測；模型 C 能有效捕捉棲位相似物種所造成之競爭效應；模型 D 則進一步納入競爭物種適應程度，提升模型解釋力。整體而言，本研究驗證了將競爭壓力與物種適應性納入 HSI 架構之可行性，並建立具泛用潛力與實務應用價值之棲地評估工具，可作為原生魚類保育、外來種管理及水利工程生態影響評估之參考依據。

關鍵詞：棲地適宜性指數、屏東五溝水濕地、條紋小鮕、淡水生態系

Abstract

This study aims to develop a multi-level habitat suitability assessment framework that integrates environmental factors, competition pressure, and species preference. The framework is used to analyze the spatial distribution and habitat suitability of a native freshwater fish, *Puntius semifasciolatus*, in the Wugoushui Wetland, Pingtung, Taiwan. First, habitat suitability indices (HSI) were built using electrofishing surveys and environmental measurements. Then,

four different models were developed by adding concepts such as invasive species pressure, ecological niche overlap, and the environmental adaptability of competing species. These models simulate different ecological assumptions related to habitat conditions and species interactions. For model evaluation, AUC curves with constrained ordination were used to test the ability of environmental variable combinations to distinguish habitat suitability. Kruskal-Wallis and Dunn's non-parametric tests were applied to compare model scores before and after construction activities, in order to evaluate how engineering events affected suitability scores. In addition, linear mixed-effects models (LMM) were used to predict changes in fish abundance in the following year. Marginal and conditional R-squared values were calculated to assess each model's ability to explain species dynamics. The results showed that Model A was stable and easy to use, and it reflected total biomass pressure effectively. Model B performed well in areas strongly affected by invasive species and is suitable for monitoring invasion pressure. Model C captured the competition effect from niche-overlapping species more precisely. Model D further included the adaptability of competing species and improved ecological explanation. In summary, this study confirms that integrating competition pressure and species adaptability into HSI models is feasible. It also provides a practical and flexible tool for habitat assessment, with potential applications in native fish conservation, invasive species management, and ecological impact evaluation of hydraulic engineering.

Keywords: Habitat Suitability Index, Wugoushuei Wetland (Pingtung), *Puntius semifasciolatus*, Freshwater Ecosystem